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TEST EQUIPMENT FOR AUSTRALIAN REBECCA M
AND EUREKA MK.II

By
E.K. Inall

P.D.47



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Ref
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AND EUREKA MK.II

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COMMONWEALTH OF AUSTRALIA
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
DIVISION OF RADIOPHYSICS

CONTENTS

	page
1. INTRODUCTION.. .. .	1-1
1.1 Service Designations.	1-2
1.2 Nature and Application of equipment	1-2
1.3 Weights, Dimensions and Power Requirements	1-3
1.4 Photograph of the Complete Equipment	1-4
2. FUNCTIONS OF THE CIRCUITS.	2-1
2.1 Control Gate Generator	2-1
2.2 Calibrator	2-1
2.3 Modulator and Calibrator Output.	2-3
2.4 R.F. Oscillator	2-3
2.5 P.R.F. Meter	2-3
2.6 D.C. Amplifier.	2-4
2.7 Diode Head	2-4
2.8 Wavemeter	2-5
2.9 Cathode Ray Oscilloscope	2-5
2.10 Power Supply	2-6
2.11 Test Antenna	2-6
3. OPERATING PROCEDURE, SWITCHING ON	3-1
3.1 Range Calibration	3-1
3.2 Squint Testing of Rebecca Aerials	3-3
3.3 R.F. Power Measurements	3-4
3.4 Field Strength Measurements	3-6
3.5 Wavemeter. . . Tuning Eureka and Rebecca transmitters	3-7
3.6 Signal Generator. . Tuning Eureka Receiver, Receiver Sensitivity	3-9
3.7 Recovery Time of Eureka Receiver.	3-12
3.8 P.R.F. Measurements.. . . .	3-13

(continued)

4.	CIRCUIT DESIGN AND DETAILS OF THE OPERATION..	page 4-1
4.1	Control Gate Generator	4-1
4.2	Range Calibration Oscillator	4-3
4.3	Pulse Modulator.. ..	4-7
4.4	Radio Frequency Oscillator.. ..	4-9
4.5	P.R.F. Meter	4-13
4.6	Wavemeter.. ..	4-15
4.7	Diode Voltmeter.. ..	4-18
4.8	D.C. Amplifier	4-18
4.9	Power Supply	4-21
4.10	Metering	4-22
5.	PRODUCTION MODELS	5-1
5.1	Test Unit and Oscilloscope.. ..	5-1
5.2	Production Aerials	5-1
6.	DIAGRAMS	
Figure 11	Circuit of Test Unit.. ..	6-1
" 12	Schematic of Cathode Ray Oscilloscope Circuit.. ..	6-2
" 13	Test Unit to C.R.O. Connector ..	6-3
" 14	Diode Head.	6-4
" 15	External view of Diode Head. ..	6-5
" 16	Internal view of Diode Head. ..	6-6
" 17	Dismantling the Diode Head.. ..	6-7
" 18	Components of the Diode Head ..	6-8
" 19	Wavemeter Assembly Drawing.. ..	6-9
" 20	External view of wavemeters. ..	6-10
" 21	Wavemeter tuning Condenser.. ..	6-11

(continued)

Figure	22	Signal Generator Assembly	6-12
"	23	External view of Signal Generator.	6-13
"	24	Internal view of Signal Generator.	6-14
"	25	Removing the chassis of the Signal Generator.	6-15
"	26	Complete Test Antenna Assembly ..	6-16
"	27	Wavemeter Calibration.	6-17
"	28	R.F. Vacuum Tube Voltmeter Calibration	6-18
"	29	Correction of Diode Head for Frequency.	6-19
"	30	Correction of Diode Head for Duty Cycle	6-20
"	31	Power Voltage Conversion Chart for 75 ohm line.	6-21
"	32	Production Aerial	6-22
"	33	Connections to Cathode Ray Oscillograph	6-23

TEST EQUIPMENT FOR AUSTRALIAN REBECCA MK.III B
AND EUREKA MK.II

By
E.K. Inall

1. INTRODUCTION

This report describes the specialised test equipment which has been developed for the Australian Rebecca-Eureka programme. The equipment is intended to carry out most of the essential tests and calibrations on these sets, both in the field, and in the workshop. It can also be applied directly to a number of other P-band beaconry, I.F.F. and radar search equipments. This test gear project does not include the provision of impedance measuring gear.

The provisional technical requirements submitted by the R.A.A.F., require a test set with a C.R.O., and auxiliary parts, to be as universal in application, and as portable as possible. In some respects the design used is not the most desirable, but this could not be avoided owing to the urgency of the project, and the lack of certain components in Australia.

The equipment is in three major units, namely, a test unit, a cathode ray oscilloscope, and test antennae.

The prototypes of the test unit and antennae were designed and constructed by the C.S.I.R. Division of Radiophysics, and the cathode ray oscilloscope was designed by the Division of Radiophysics and the Gramophone Co. Ltd., and constructed by the Gramophone Co. Ltd.

1.1 Service Designations

The R.A.A.F. designate the complete equipment.

Test Set Type RE1 Ident. No. Y10SB/500125. This consists of

- (i) Test Unit type A1053 for Test Set Type RE1 Ident. No. Y10SB/500133.
- (ii) Oscilloscope Cathode Ray Type A1054 for Test Set Type RE1 Ident. No. Y10SB/500134.
- (iii) The antenna assembly.

1.2 Nature and Application of Equipment

The test unit incorporates:-

- (a) Wavemeter
- (b) Diode Voltmeter
- (c) Range Calibrator
- (d) Pulsed H.F. oscillator, which will generate range marker pulses,
- (e) P.R.F. meter
- (f) Power unit,

and the C.R.O.:-

- (a) Cathode ray tube
- (b) Triggered high speed timebase
- (c) Video amplifier
- (d) Blanking circuit.

The test antenna assembly consists of two dipoles which can be tuned to any frequency between 150 and 250 Mc/s. The dipoles, with matching lines, are mounted on a tripod and can be rotated to suit both vertical and horizontal polarisation.

Among the tests which can be made on Rebecca-Eureka sets are:-

- (a) Receiving and transmitting frequencies
- (b) Transmitter power and radiated field strength
- (c) Receiver performance
- (d) Rebecca range calibration
- (e) Eureka recovery time
- (f) Directional diagrams of antennae and squint of Rebecca fitted aircraft
- (g) Waveforms, pulse shapes and pulse lengths
- (h) P.R.F.
- (j) I.F.F. Suppression.

1.3 Weights Dimensions, and Power Requirements

- 1.3.1 Weights, Test unit
- | | |
|--------------------------|-----------|
| Cathode Ray Oscillograph | - 48 lbs. |
| Antenna Assembly | - 9½ lbs. |
| | - 11 lbs. |

1.3.2 The overall dimensions of these units are,

Test Unit :- 15¼" by 11" high, by 13½" deep

Cathode Ray Oscillograph 8" by 8¾", by 12"

and the antenna packs into a bundle of rods 2 feet long by about 6" diameter.

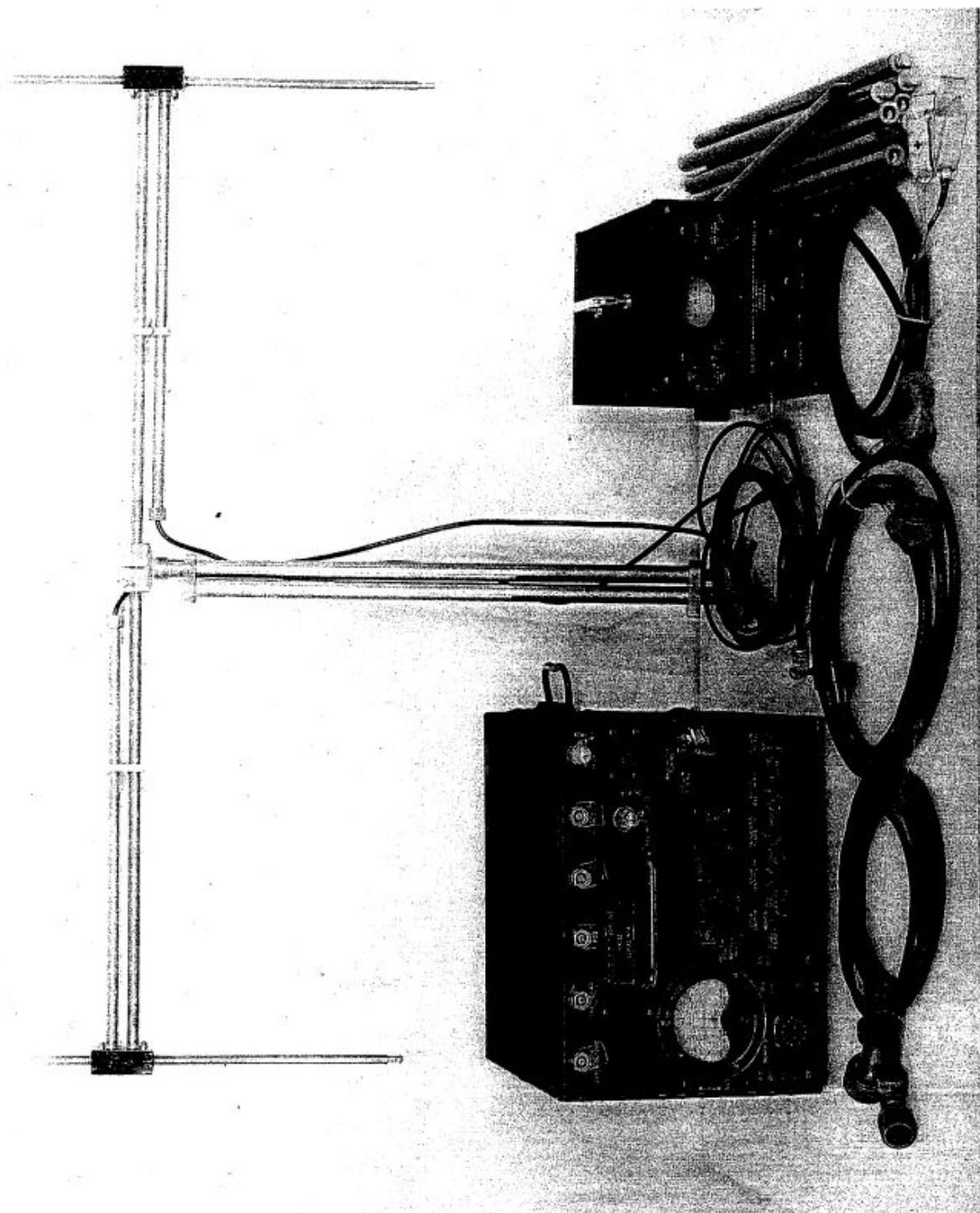
1.3.3 The maximum power requirements of the set are,

0.7 Amps at 240 Volts 50 c.p.s. A.C.

or 1.25 Amps at 80 Volts 200 to 2,000 c.p.s. A.C.

or 4.2 Amps at 24 volts D.C.

Three cables are supplied with each set, one for each type of mains supply. The cable for 240 Volt A.C. is fitted with a 3-pin plug, the 80 Volt A.C. with a 4-pin W connector and the 24 Volt D.C. with large battery clips. The correct cable must be used for each type of supply.



1.4 Complete Equipment

2. FUNCTIONS OF THE CIRCUITS

There are two types of functions performed by the test set. Firstly there are those which must be synchronised with external circuits, and secondly there are measurements which are continuous and independent of timing. Grouped in this way the functions of the test set are:

Synchronised

- (1) Range Calibration.
 - (a) Test set is triggered by R.F. or Video pulse and generates R.F. or Video Calibrator pips.
 - (b) Test set self timed delivering a sync. pulse and R.F. or Video Calibrator pips.
- (2) Triggered C.R.O. which can be synchronised from an external circuit or can be self timed and supplying a synchronising pulse.
- (3) Pulsed Signal generator for testing the sensitivity of a receiver with C.R.O. presentation synchronised to the test set.

Unsynchornised

- (1) Measurement of frequency in the range 150-250 Mc/s. with a reading accuracy of $\pm \frac{1}{20}$ Mc/s.
- (2) P.R.F. meter to measure the repetition rate of a video or R.F. signal.
- (3) R.F. Power into a 75 ohm load.

Refer to the complete circuit, figure 11 (p.6-1) and the block diagram of figure 1 (p.2-2).

2.1 Control Gate Generator

The synchronised functions are controlled by a gate generated by V1 which may operate as a 350 c.p.s. multi-vibrator or as a triggered generator, triggered by a positive or negative pulse or the envelope of an R.F. pulse.

2.2 Calibrator

The negative gate, which is 1500 μ secs long switches the range calibrator or alternatively it is differentiated and triggers the pulse modulator. A Hartley oscillator generating the distorted sine wave shown in figure 5 (p.4-6) controls the calibrator. This wave form is squared by V2A, and differentiated to give a train of pulses shown in figure 5 (p.4-6). These pulses trigger the modulator.

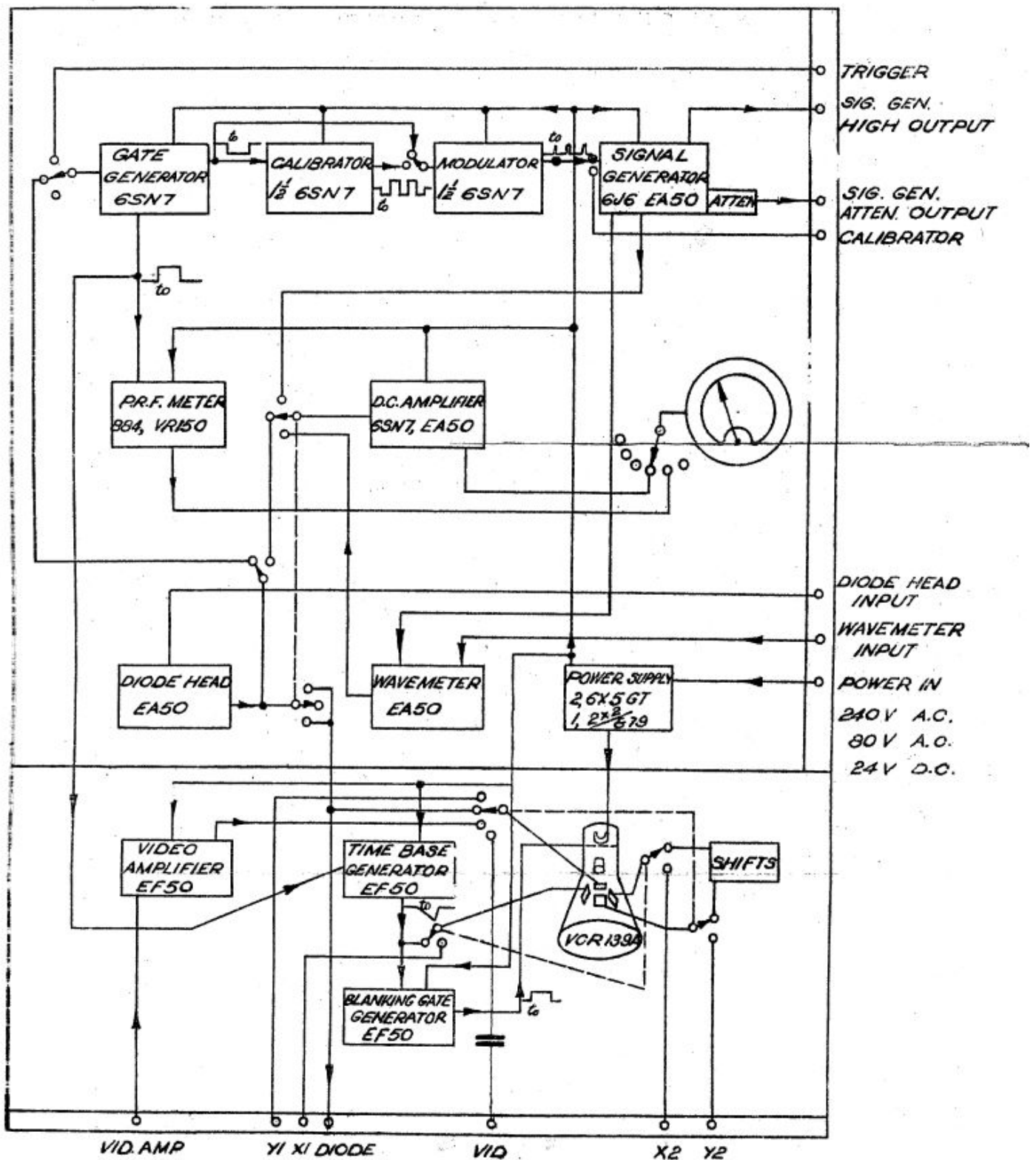


FIG. 1

2.3 Modulator and Calibration Output

The pulse modulator is a cathode coupled pulse generator consisting of V4 and one unit of V3. When the negative pip from V1 or the train of pips from the calibrator trigger this modulator it generates positive pulses 2.2 microsec. long. These may be coupled to the grid of the R.F. oscillator or to the RANGE CAL. OUTPUT plug on the front panel.

The voltage waveform at the anode of the modulator is shown in Figure 6. (p.4-8). These pulses, reduced to 15 Volts amplitude by R64 and R64A are used as the video range calibration markers which are shown in Figure 6. To increase the amplitude of these markers reduce the value of R64A.

The markers are spaced at $\frac{1}{2}$, 1, 5, or 10 nautical mile intervals. This spacing is accurate to $\pm 1\%$. If, however the test set is being triggered by other equipment the first pulse of the train may be delayed about 0.25 microsecs.

2.4 R.F. Oscillator

The R.F. oscillator, which covers the range 170 to 240 Mc/s., uses a 6J6 with lechers tuned by a split stator condenser coupled to the anodes. It is well shielded and the power leads filtered, and therefore serves as a simplified signal generator which will generate C.W. or pulse modulated R.F. A permanent connection to the wave-meter enables the frequency to be set accurately, while the amplitude of oscillation of the generator is monitored by means of a diode V10 in conjunction with the D.C. amplifier V7.

Two outputs from the generator are provided, one giving an output of up to 1.5 Volts into a 75 Ω load. This is sufficient signal to enable aerial diagrams and impedance measurements to be made. The other outlet is by way of a piston attenuator which gives a maximum output of -10 db. from 0.1 Volts into an impedance of 75 Ω . This attenuator reads down to -90 db. with an accuracy of ± 3 db. and can therefore be used to check receiver performance and cable system losses etc.

2.5 P.R.F. Meter

The repetition frequency at which the gate from V1 is generated is measured by differentiating and applying it to the grid of the thyatron V5. This discharges C7 through the meter, V5 then ceases to conduct and C7 charges with a time constant of 700 μ sec. reaching 95% of the supply voltage

in 2,000 μ sec. The meter reads up to 500 c.p.s. at which figure the 5% error is corrected by a contraction of the scale.

2.6 D.C. Amplifier

The R.F. voltage across a 75 ohm feeder and the frequency of an R.F. signal in the 150 to 250 Mc/s. range are measured with the diode head U858 and the wavemeter U856. The indicator used in each case is the D.C. amplifier V7 in conjunction with a 0-1 mA meter.

The input grid of the amplifier always connects to the anode of an EA50 the emission of which maintains this grid slightly negative with respect to earth. The effect of this bias is balanced out by another EA50, V8.

1½ Volts applied to the grid of V7 results in full scale deflection of the meter and the range is extended up to 300 Volts by the use of a resistive attenuator.

2.7 Diode Head

The diode head is a completely enclosed unit (see page 6-4 and 6-5) with a resistive input of 75 Ω . The voltage across the input is applied to the anode of an EA50 (V11) the cathode of which connects to earth. The rectified voltage at the anode is brought out through the low pass filter L18 and C56 which stops the leakage of R.F. but gives a video frequency response up to 2 Mc/s. when used with the 2,000 Ω load in the C.R.O. In which case the amplitude of the envelope of an R.F. pulse is 0.75 of the peak R.F. voltage. The envelope may be used to trigger the gate generator and thereby synchronise the test unit to the source of the R.F. pulse or it may be integrated by C14 for power measurements.

One third of a watt is the maximum power that can be absorbed by the diode head so that it can be used to measure C.W. signals of up to 7 Volts peak. When measuring pulsed power the meter reads a certain fraction "a" of the peak voltage. The variation of "a" with duty cycle is shown in calibration sheet 9 pages 6-20. Voltages of up to 400 Volts can be measured if the duty cycle is such that the mean power is less than $\frac{1}{3}$ watt. The inductance of the leads to V11 resonates with the interelectrode capacity at about 300 Mc/s. this causes the voltage across the interelectrode space to exceed the input voltage by an amount depending on the frequency. This error is corrected for by the use of a factor "b" which varies with frequency according to the curve on

calibration sheet, 8, page 6-19.

2.8 Wavemeter

The wavemeter consists of a length of coaxial line slightly shorter than a quarter wavelength at 250 Mc/s., shorted at one end and tuned by a variable condenser at the other. This condenser is operated by a worm drive which requires ten revolutions to cover the tuning range 150 to 250 Mc/s. Mounted on this drive is a scale which is marked with 10 large divisions subdivided into 10 to give a total of 100 small divisions representing $\frac{1}{10}$ Mc/s. per division. This provides a reading accuracy of $\pm \frac{1}{20}$ Mc/s. Referring to figure No.19 page 6-9, it will be seen that one of two loops mounted near the shorted end of the line may be used to couple power into the wavemeter. The voltage developed across the open end of the tuned circuit is capacity coupled to the anode of V12. When the wavemeter is tuned to the applied signal resonance causes a sharp rise in the rectified voltage at this anode which, applied to the grid of V7 gives an increase in the meter reading.

2.9 Cathode Ray Oscilloscope

The Cathode Ray Oscilloscope is a small unit designed to clamp onto the test unit, the connector shown on page 6-3 providing six interconnecting circuits. The unit incorporates a C.R.T. VCR139/A, a variable gain video Amplifier, a time base generator and blanking gate generator, as shown in figure 1 page 2-2 and the circuit on page 6-2.

The anode supply to the VCR139/A is about 700 volts giving a sensitivity of 100 volts per inch. Switches in the deflection plate circuits enable signals to be applied to the plates directly or through the video amplifier and also provide an internal connection from the diode head in the test unit to the vertical deflection plate.

The gain of the video amplifier is adjusted by varying the value of the cathode resistor. When the gain is a minimum of 0.6 the tube is a cathode follower with a small anode load. In this case the circuit will handle 35 volts. of negative signal or 80 volts of positive and the shunt capacity of the input circuit is about 15 p.f. With the gain at its maximum of about 15 the circuit will handle a negative pulse of about $3\frac{1}{2}$ volts and a positive one of 8 volts. The input capacity is then 30 p.f.

The time base is generated by a phantatron controlled by the gate from the test set. It provides linear negative sweeps of 12, 48, 120 or 1200 microseconds duration which are

applied to one horizontal deflection plate and which are also differentiated and coupled to the grid of the blanking gate generator V3.

2.10 Power Supply

The power requirements for the system described above are

80 mA at 300 Volts for anode supplies
3 mA at 700 Volts for C.R.T. operation

1.95 Amps at 24 Volts for heaters
1.75 Amps at 2.5 Volts for 2 X 2 heaters
1.1 Amps at 4.0 Volts for C.R.O. heaters

This is provided by a power supply which operates from 0.7 Amps at 240 V 50 cycles/sec. A.C., 1.25 Amps at 80 Volts 400-2,000 cycles/sec. A.C., or 4.2 Amps at 24 Volts D.C. When operating from D.C. a 24 Volt vibrator is used! To prevent noise generated by the vibrator interfering with communication equipment or triggering Eureka, the power supply is completely enclosed and leads from it are filtered.

2.11 Test Antenna

The test antenna assembly is shown on page 6-16. It is set up in front of the Rebecca fitted aircraft to check for aerial squint, to test the transmitting and receiving systems, and to adjust range calibration.

For these tests the set is triggered by the R.F. pulse from Rebecca which is received in one dipole, while the second dipole is used to radiate the train of R.F. pulses generated by the signal generator.

3. OPERATING PROCEDURE, switching on

Select from 24 volts D.C., 80 volts 200 - 2000 ~ A.C. or 240 volts 50 ~ A.C. the type of mains supply which will be most convenient, and attach the appropriate cable to the twelve pin connector on the front panel. The 24 volt cable has battery clips at the supply end, the polarity of connection does not matter. The 80 volt A.C. lead terminates in a four pin w connector and the 240 volts has a three pin plug. When the correct cable is connected to the mains the set is switched on by the appropriate one of the two switches at the side of the input plug.

3.1 Range Calibration of Indicators

The range marks produced by the test set are spaced at $\frac{1}{2}$, 1, 5 or 10 nautical miles, the required value being selected by switch S2C. It was stated in § 2 that the calibrator can be triggered by

- (a) A positive pip of 20 volts or greater,
- (b) A negative pip of 15 volts or greater,
- or (c) A short pulse of R.F. energy of 15 volts R.M.S. or greater

and it then gives out range markers in the form of

- (a) +15 volts pulses 2 μ sec. long.
- or (b) R.F. pulses 1.5 μ sec. long.

Alternatively the test set may be self triggering. It then provides the range markers as above and both a positive and a negative sync. pulse either of which may be used to trigger the indicator circuits. These sync. pulses are obtained from the same plugs as are used to trigger the set.

Of the many ways in which these methods of operation can be used one of the following will usually be most satisfactory.

3.1.1 The radar system operating and supplying a

positive or negative sync. pulse to the test set. Video pips are applied to the video circuit of the indicator.

Then the units should be connected by

- (a) A sync. cable from the radar set to TRIGGER POS or TRIGGER NEG on the test set.
- (b) A video lead from RANGE CAL OUTPUT of test set to VIDEO IN on the indicator.

Switch S1 to VIDEO,
S2 to $\frac{1}{2}$, 1, 5 or 10 as required,
and S3 to OFF.

3.1.2 An indicator which requires a synchronising signal from an external circuit is calibrated by using the test set as the timing circuits as well as to supply the calibration markers.

Connect

- (a) A cable from TRIGGER NEG or TRIGGER POS on the test set to the SYNC IN of the indicator.
- (b) A cable from RANGE CAL OUTPUT on the test set to VIDEO IN of the indicator.

Switch S1 to SELF
S2 to $\frac{1}{2}$, 1, 5 or 10 as required
S3 to OFF.

This will give a time base with suitable markers to enable the time base speed to be set to the required value.

3.1.3 Calibration with the complete radar system operating as in normal service. Set up the test aerials as shown on page 6-16 in the radar beam, and set the plane of polarization to that of the radar aerials.

Connect

- (a) A cable from one dipole to the test set
DIODE HEAD INPUT.
- (b) A cable from the second dipole to
SIG. GEN. ATTEN. OUTPUT of test set.

Switch S1 to R.F.
 S2 to $\frac{1}{2}$, 1, 5 or 10 as required
 S3 to TRIGD
 S4 to SIG. GEN. AMP.
 S6 to R.F. VTVM.

Turn SIG. GEN. AMPLITUDE up until the meter reads about full scale, and turn ATTENUATOR CONTROL to 10 db.

Switch S4 to WAVEMETER
 S1 to range No.1 and zero the meter by means of VTVM ZERO control.

Set the WAVEMETER TUNING to the radar frequency.
 (The frequency of the transmitter may be measured by means of the wavemeter as described in § 3.5 if it is not known.)

Tune the signal generator until the meter indicates a peak. The frequency is then about the same as that on which the radar is operating.

Tune the receiver to give maximum size markers on the screen and then turn ATTENUATOR CONTROL of test set down to give a suitable size. About 40 - 50 db. down should be satisfactory.

The arrangement of equipment used for this calibration is the same as required to check aerial squint of a Rebecca fitted aircraft and these two tests can be made consecutively with the one set up.

3.2 Squint testing of Rebecca Aerials

That is, to check that the signal from a beacon

directly ahead of the aircraft will produce equal deflections on both the port and starboard traces.

Place the antenna assembly shown on page 6-16 in front of the aircraft accurately on the axis. When the adjustments described in § 3.1.3 have been carried out two series of marker pips, one to the left and one to the right of the indicator trace, appear on the screen. If the Rebecca aerials are correctly adjusted the amplitude of these two series of markers should be equal.

A more detailed check on the aircraft's ability to "home" may be made by moving the test dipole to points on a bearing of 5° , 10° , 15° , etc from the dead ahead line of the craft and noting the ratio of amplitude of the two sets of markers. As the dipole is moved off to starboard the starboard markers should increase and the port decrease.

3.3 R.F. Power Measurements

3.3.1 C.W. Measurements

The input to the diode head is matched to a .75 ohm cable and can absorb $\frac{1}{2}$ watt of power which is equal to a peak voltage reading of 7.1 volts. The lowest voltage which can be measured is about 0.05 volts. Within these limits the accuracy of the readings is about $\pm 10\%$ or ± 1 db.

Couple the power to be measured into the
DIODE HEAD INPUT and

Switch S1 to SELF or VIDEO
S4 to DIODE HEAD
S5 to range No. 1, 2 or 3 as required to give
a suitable meter reading.

The peak R.F. voltage is then determined from Calibration Curve No. 2, 3 or 4 depending on the setting of S5. These curves are correct when the radio frequency is 210 Mc/s. At other frequencies there is a small error which can be corrected for by multiplying by the factor "p" the value of which is given by calibration curve No. 8 (page 6-19)

so that,

Peak R.F. Voltage = V_p = "b" x Voltage from Calibration curve.

3.3.2 Measurements of Pulsed Power

Provided the mean power is not greater than $\frac{1}{2}$ watt, pulse modulated power of up to 300 volts can be measured as described in § 3.3.1. However in this case the meter does not read the peak voltage and a correction factor "a" which depends upon the duty cycle of the power must be used. (The duty cycle is the ratio of the pulse length to the period between the start of two successive pulses

i.e. duty cycle = Pulse length in sec. x p.r.f.).

Values of "a" are plotted against duty cycle in calibration curve No.9 (page 6-20).

The peak voltage is therefore given by

V_p = Voltage from Calibration curve x "a" x "b".

3.3.3 Power Output of Eureka

To make use of the method of measurement described in § 3.3.2 Eureka must be triggered by an R.F. pulse at a known repetition rate. To do this connect the SIG. GEN. ATTEN. OUTPUT of the test unit to the Eureka receiver input and the transmitter output of Eureka to the DIODE HEAD INPUT of the test set.

Switch	S1	to	SELF
	S2	to	OFF
	S3	to	TRIGD
	S4	to	DIODE HEAD
	S5	to	Range No. 4
	S6	to	R.F. VTVM.

Turn SIG. GEN. AMPLITUDE well up and set ATTEN. CONTROL to give maximum output (-10 db.). Jack in the Eureka earphones and adjust the SIG. GEN. TUNING until

a 350 cycle per sec. note indicates that that Eureka is being triggered. Turn the ATTEN. CONTROL down until triggering begins to become erratic and then check the SIG. GEN. TUNING to give most stable operation. Now turn the ATTEN. CONTROL up again until Eureka is triggered stably at 350 c.p.s.

The power output is then determined as described in § 3.3.2.

The pulse lengths of Eureka is about $7.5\mu\text{sec.}$ so that for this test

$$\begin{aligned}\text{Duty Cycle} &= \frac{7.5 \times 350}{10^6} \\ &= 2.6 \times 10^{-3}\end{aligned}$$

Therefore the voltage found from the calibration sheets must be multiplied by "a" = 1.52 (see curve page 6-20) to give the peak voltage.

3.4 Field Strength Measurements

Calculations of the power output of a transmitter from field strength measurements described in this section are rarely more accurate than ± 3 db., however, when considered in conjunction with direct measurements of the power generated they do indicate the performance of the feeder and aerial system and the way the transmitter functions when loaded by the aeriels.

When a vertically polarized radio wave strikes a surface such as the earth at an angle known as the Brewster angle most of the energy penetrates the surface. The value of the Brewster angle depends on the frequency and the electrical properties of the surface. For Eureka frequencies and the average ground it is about 15° . This means that the field strength at a height of nine feet and 70 feet from the Eureka aerial (height 10 feet) is the same as if the aerial

were a dipole in free space. This field strength can therefore be calculated in terms of transmitted power.

Thus if Eureka is radiating 30 watts a peak voltage of 0.54 volts should be received in a dipole at 70 feet. Measure this by erecting the Eureka and test aerials 70 feet apart and well clear of reflecting objects. Connect them to the equipments so that one test dipole couples into the diode head and the other connects to the SIG. GEN. ATTEN. OUTPUT.

Switch	S1	to	SELF
	S2	to	OFF
	S3	to	TRIGD
	S4	to	DIODE HEAD
	S5	to	Range No. 1
	S6	to	R.F. VTVM

and by means of an extension lead on the earphones or with the help of another operator, adjust the signal generator to trigger Eureka and measure the voltage received as described in § 3.3.3 using space transmission instead of a direct connection.

When measuring the field strength of radiation from Rebecca the Brewster angle effect will occur if the test dipole is 55 feet from the transmitting aerials. In this case when Rebecca is radiating 300 watts the peak voltage received should be about 2.2 volts if the aerial has no director.

3.5 Wavemeter. Tuning Eureka and Rebecca Transmitters. (150 Mc/s. to 250 Mc/s.)

3.5.1 Frequency Measurements

Remove the cover from the WAVEMETER INPUT and couple in the signal

Switch	S4	to	WAVEMETER
	S5	to	Range No. 1
	S6	to	R.F. VTVM

Set the meter to zero by means of VTVM ZERO then

tune the wavemeter until the meter reads a maximum. If the meter tends to read more than full scale switch S5 to range No. 2, 3 or 4 etc until a maximum reading less than full scale can be obtained.

The frequency is then found by reading the drum and dial scales above the tuning control and determining the frequency from the calibration curve No. 1 (page 6-17).

3.5.2 Frequency of Rebecca and Eureka

The frequency of most transmitters is markedly affected by the loading, and therefore frequency measurements and adjustments should be made while under load conditions. This is particularly important in the case of Rebecca and Eureka since they each have to be set on frequency by means of a wavemeter and can rarely be tuned one to the other.

To measure the frequency of Rebecca erect the test dipole in a position where it will couple lightly to the transmitting aerial and connect its cable to the wavemeter input. If it is necessary to adjust Rebecca the dipole can be placed beside the fuselage near the observer's cockpit and the test set taken inside. The frequency is then measured as described in § 3.5.1.

To check frequency of Eureka erect the Eureka and test set aeriels side by side, and connect them to their equipments (as shown in Figure 2 page 3-10). With the sets working press the TEST button on the Eureka panel and determine the operating frequency as described in § 3.4.1. When the TEST button is held down for long periods several components in Eureka are over-loaded. If therefore it is necessary to tune the transmitter, Eureka should be triggered by the test set. In this case erect the aeriels as above, jack the phones into Eureka, and connect the cable from the second test aerial to the SIG. GEN. ATTEN. OUTPUT of the test set.

Switch	S1	to	SELF
	S2	to	OFF
	S3	to	TRIGD
	S4	to	WAVEMETER
	S5	to	Range No. 1
	S6	to	R.F. VTVM.

Turn SIG. GEN. AMPLITUDE control well up and set ATTEN.CONTROL to its maximum. Switch Eureka receiver frequency to a range other than that to which the transmitter is to be tuned, and adjust the signal generator controls as described in § 3.3.3.

When these adjustments have been made Eureka should be transmitting. Tune the wavemeter to the transmitter making sure that the indication observed is not due to the signal generator which is connected internally to the wavemeter. To check this, remove the cable connecting the dipole to the wavemeter and note whether the meter reading disappears.

3.6 Signal Generator. Tuning Eureka Receiver, Receiver Sensitivity

3.6.1 C.W. Operation

Switch	S3	to	C.W.
	S4	to	WAVEMETER
	S5	to	Range No. 1
	and S6	to	R.F. VTVM.

Tune the wavemeter to the required frequency, set the meter to zero by means of VTVM ZERO and turn the SIG. GEN. AMPLITUDE control well up. Now tune the signal generator until the wavemeter indicates that it is on frequency and then switch S4 to SIG. GEN. AMP. Stop the signal generator by turning the SIG. GEN. AMPLITUDE control right down and then set the meter to zero again. Adjust the SIG. GEN. AMPLITUDE until the meter reads the value given in the instruction sheets for that particular set. Finally check the frequency by switching S4 back to WAVEMETER and touch up the SIG. GEN. TUNING as required, then switch back to SIG. GEN. AMPLITUDE. The

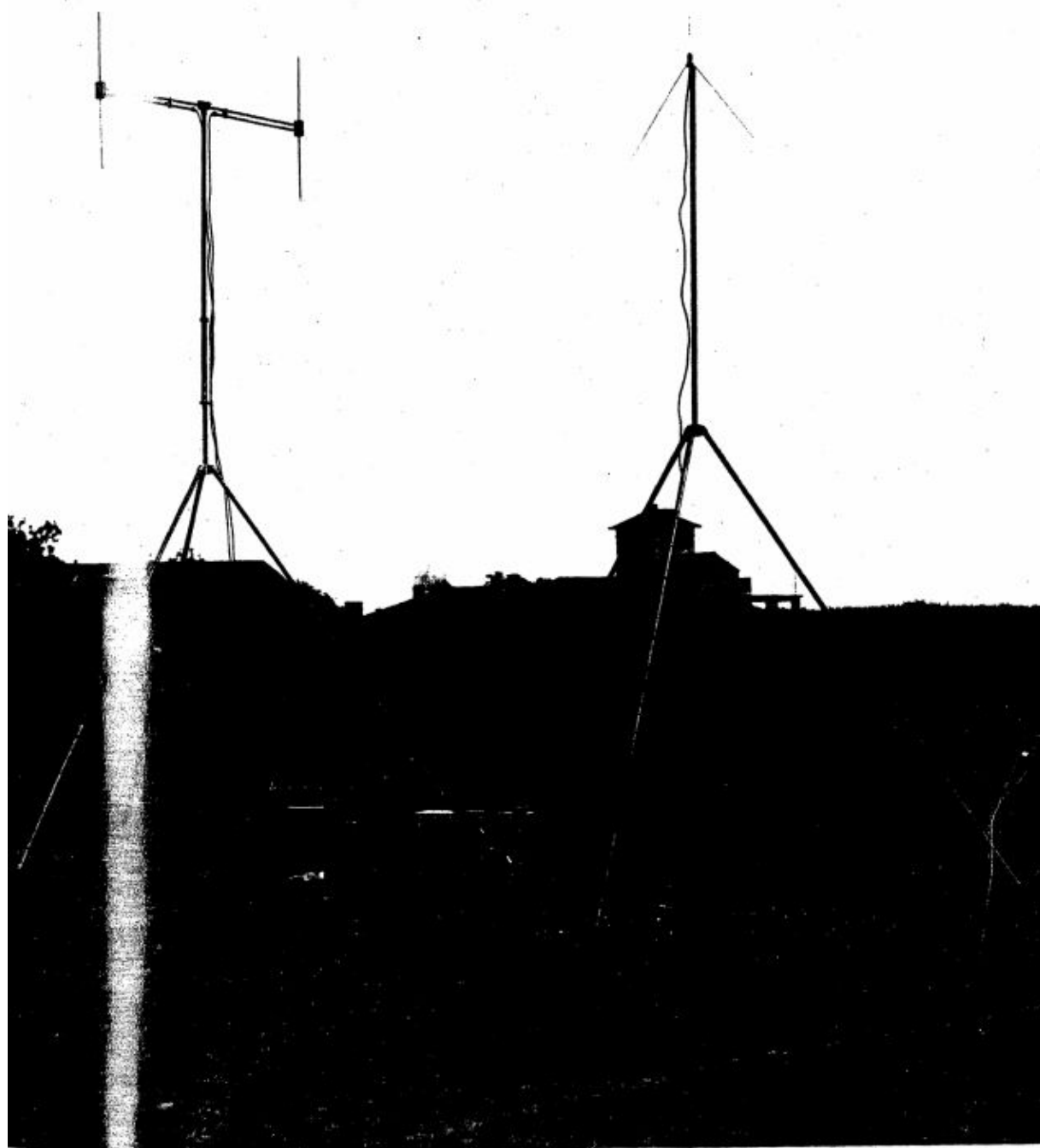


Figure 2. TUNING THE EUREKA TRANSMITTER

output from the SIG. GEN. ATTEN. OUTPUT can then be adjusted by means of the ATTEN. CONTROL the dial of which reads in db. down from 0.1 volts.

3.6.2 Pulsed Operation

For pulsed operation it is most convenient and reliable to monitor the signal generator with the calibrator set to give markers at one mile intervals (see § 4.5.3). Therefore, set S1 as required to synchronise the equipments and connect the appropriate synchronising cables, then switch S3 to C.W. and set the signal generator approximately to frequency as described in § 3.6.1, page 3-10..

Switch	S2	to	1 (mile)
	S3	to	TRIGD
	S4	to	SIG. GEN. AMP.
	S6	to	R.F. VTVM

and adjust SIG. GEN. AMPLITUDE until the meter reads the required value. Check the frequency by switching S3 to WAVEMETER and make any small adjustment which may be required.

3.6.3 Tuning the Eureka Receiver

Couple the output from the SIG. GEN. ATTEN. OUTPUT to the receiver input of Eureka. Jack the earphones into Eureka, switch S1 to SELF and adjust the signal generator to the correct output at the frequency to which Eureka is to be tuned (see § 3.6.2), and then set S2 to OFF. Reduce the attenuator output until Eureka is being triggered intermittently and then tune the receiver until the most stable operation is obtained. If Eureka is not triggered when the attenuator is turned to give a maximum output swing the signal generator frequency over a few megacycles until it is triggered. When this frequency is found switch S' to WAVEMETER and bring the signal generator back towards the correct frequency until triggering becomes erratic. Tune the receiver to the signal generator and again move the signal generator back towards the required frequency. These operations should be

repeated until the receiver is correctly tuned.

After tuning the receiver its sensitivity should be such that it is triggered by every pulse of amplitude equal to or greater than -56 db. from 0.1 volts.

3.7 Eureka Receiver Sensitivity and Recovery Time

The method of measuring receiver sensitivity described above is not accurate because the earphones do not indicate the exact level at which the set is triggered by every pulse. A more accurate determination of receiver sensitivity along with the recovery time can be made using the cathode ray oscilloscope.

Insert a telephone plug in the jack on the Eureka panel and connect it to the VIDEO AMPLIFIER INPUT (see Fig.33 photograph on page 6-23). Select the 12 μ sec. time base and VID. AMP. by means of the respective switches and turn the VID. GAIN full up. Proceed to tune the receiver as described in § 3.6.2 using the cathode ray oscilloscope instead of the earphones to indicate when the set is being triggered.

The time base is controlled by the test set so that a trace is generated each time an R.F. pulse is coupled into Eureka therefore when every pulse triggers Eureka the pulse appears as a complete displacement of the start of the trace but when Eureka is not being completely triggered some sweeps of the trace are left undeflected.

The recovery time of the receiver should be about 60 to 70 microseconds. Having measured the sensitivity, check the recovery time by switching S2 to 1 mile and selecting the 120 microsecond time base. Adjusted in this way the test unit starts the time base and 12 microseconds later gives out a pulse of R.F. which triggers Eureka and so causes a pulse to appear on the screen. The test set continues to deliver pulses at 12 microsecond intervals but these do not affect the receiver until it has recovered from the bias generated by the first pulse. If the recovery time is 60 μ sec. the sixth pulse will trigger the Eureka modulator

and a second pulse will appear on the screen. The time interval between these pulses will then indicate the recovery time required by the receiver to an accuracy of $\pm 12\mu\text{sec.}$

3.8 P.R.F. of a Video or R.F. Pulse

3.8.1 Video Pulse

Couple the pulse (positive or negative) into the appropriate connector, either TRIGGER POS or TRIGGER NEG.

Switch S1 to VIDEO
and S6 to P.R.F.

The repetition frequency is then read directly from the top scale of the meter.

3.8.2 R.F. Pulse

Couple the pulse, from the transmitter directly or from a dipole in the radiated field, into the DIODE HEAD INPUT and

Switch S1 to R.F.
and S6 to P.R.F.

Then the repetition rate is read directly from the top scale of the meter.

4. CIRCUIT DESIGN AND OPERATION

4.1 Control Gate Generator

Consider first the triggered generator.

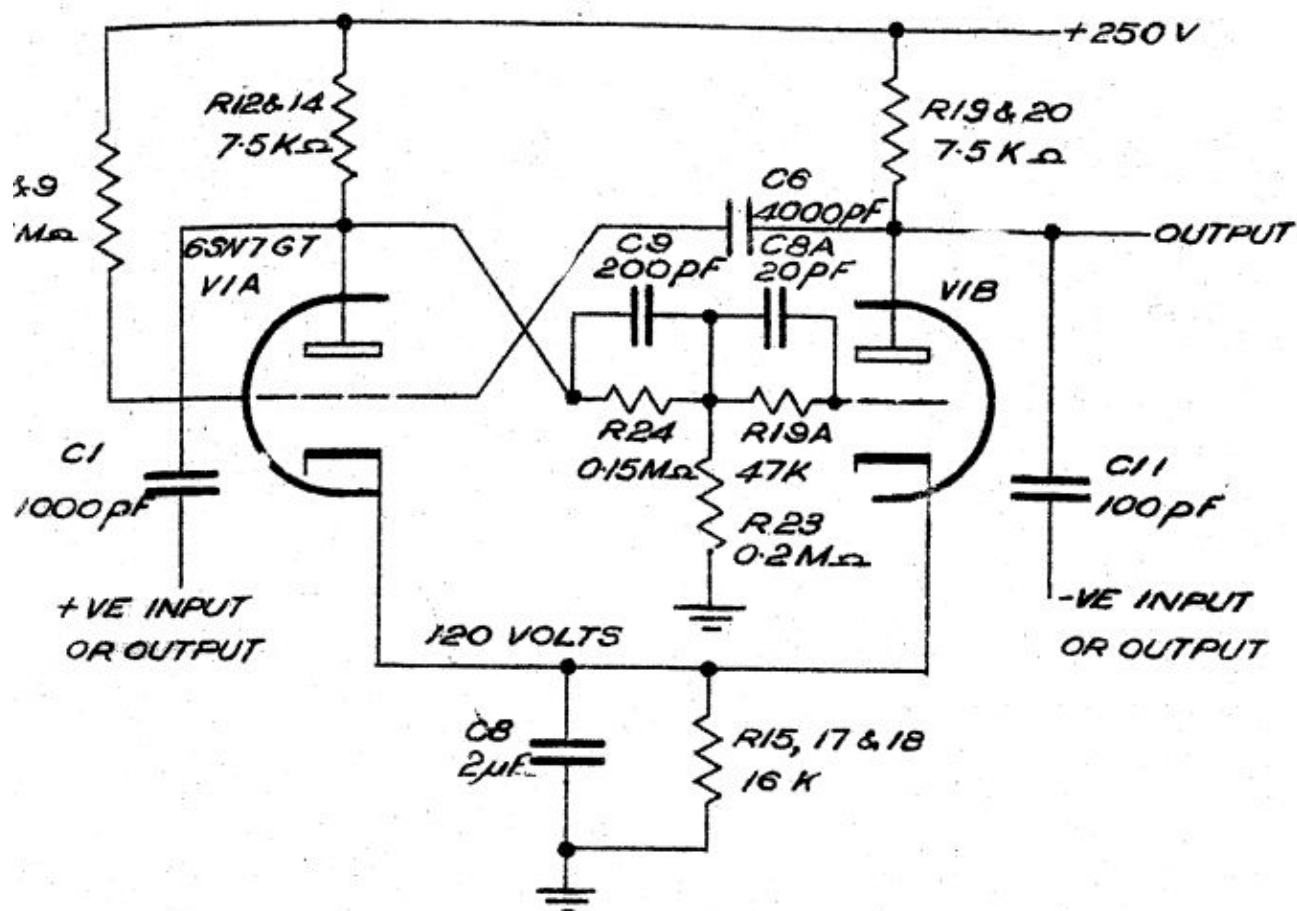
A simplified circuit is shown in Figure 3, page 4-2 from which switches and multivibrator components have been omitted.

The two triodes are the two sections of a 6SN7GT tube V1. In the waiting or stable condition the grid voltage of V1A is determined by the drop across R7 + R9 which is such that the grid-cathode potential is just at the grid current point. The cathode voltage is then determined by the anode current of V1A and the cathode resistors R15, R17 and R18.

The grid voltage of V1B is held by R24 and R23 at $\frac{2}{3.5}$ of the anode voltage of V1A, while its cathode is at the same potential as that of V1A. These voltages are such that the grid of V1B is negative with regard to its cathode by an amount just sufficient to stop this tube conducting.

A negative pulse applied to the anode of V1B is coupled by C6 to the grid of V1A. This causes the anode current of V1A to decrease and the anode voltage to rise carrying with it the grid of V1B so that V1B conducts and the anode of V1B and the grid of V1A fall rapidly until the anode current is limited by the tube characteristics and the anode load, by which time the grid of V1A is well below cut-off.

The circuit remains in this steady condition while the grid potential of V1A approaches the H.T. supply voltage with a time constant of 4,600 μ sec. as shown in Figure 3. It reaches the cut-off voltage of -14 volts in a period of about 1800 μ sec. after which V1A conducts, its anode voltage falls and cuts off V1B so that the grid of V1A is driven positive with regard to its cathode. Grid current soon restores the grid to the cathode potential so that the circuit is restored to the stable waiting condition until the next trigger pulse occurs.



TRIGGERED GATE GENERATOR

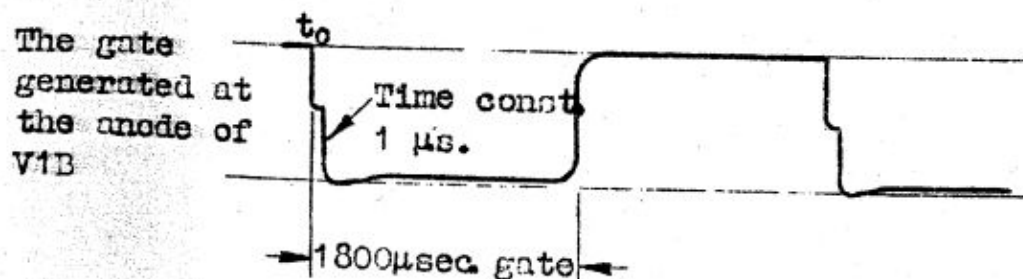
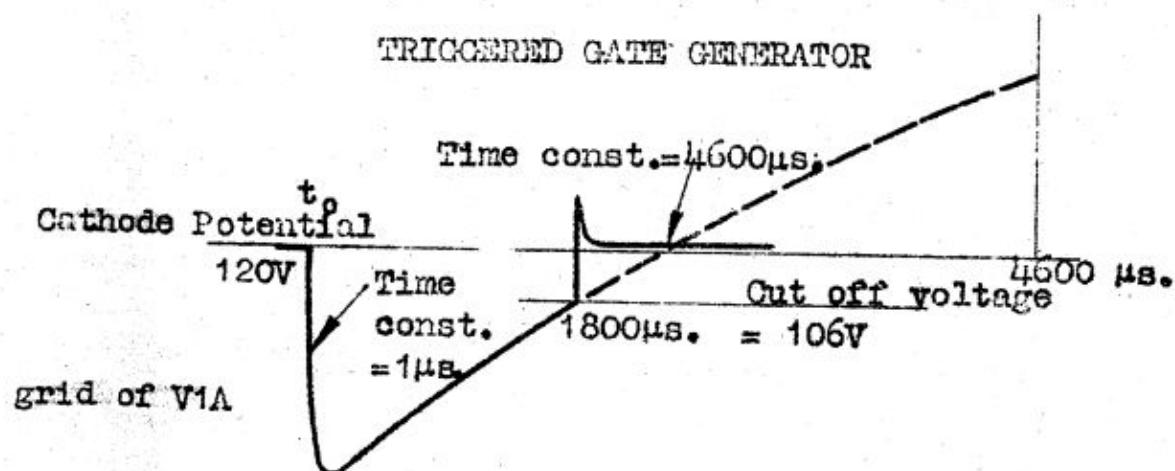


FIG. 3

A positive pulse applied to the anode of V1A has to be developed across the conducting resistance of the tube and therefore has to be powerful and is coupled through a 1000 pf condenser. Such a pulse causes V1B to conduct and the complete circuit goes through the cycle described above. The large condenser C1 loads the anode of V1A so that it rises with a time constant of about $7\frac{1}{2}$ μ sec. but does not affect the negative gate at the anode of V1B.

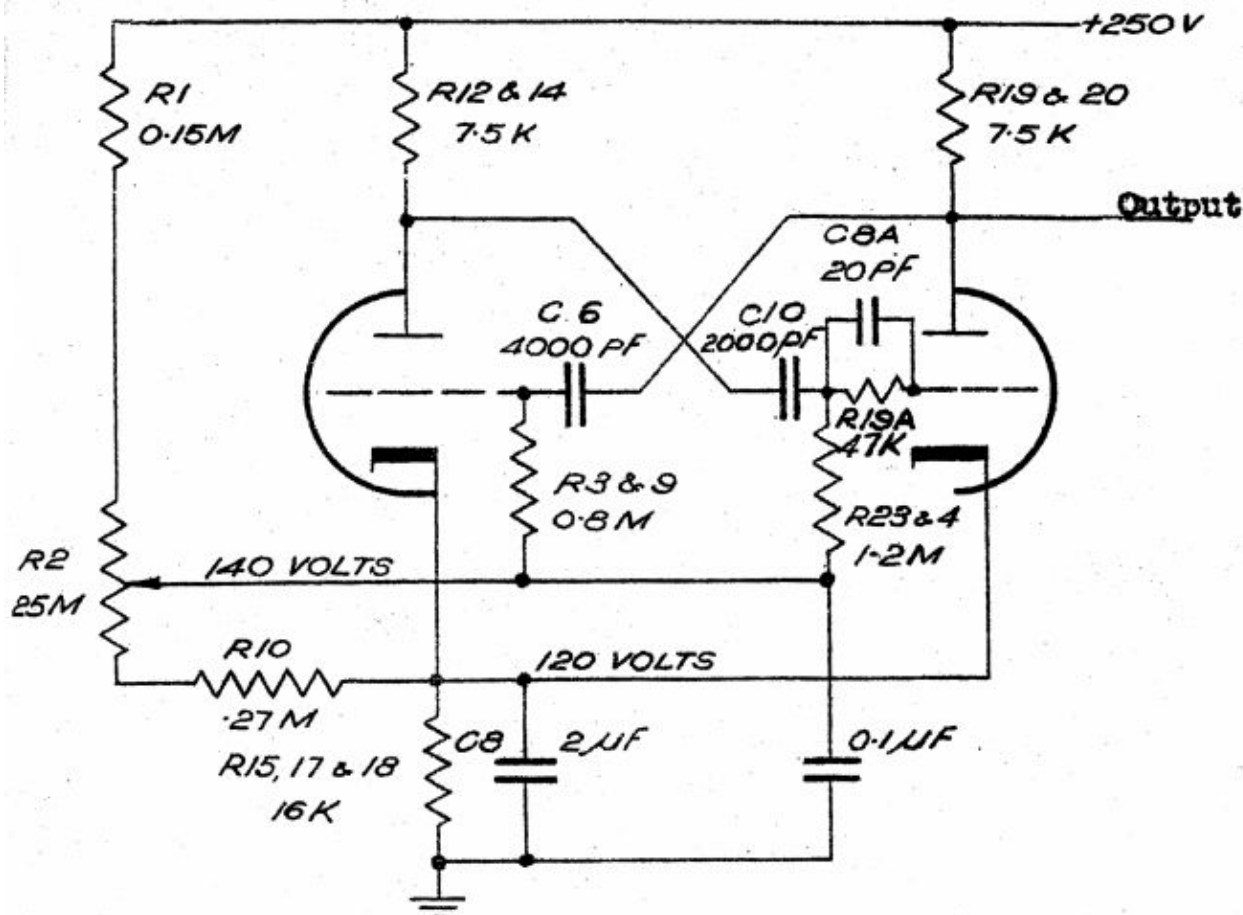
The output in each case is a negative gate of about 60 volts amplitude and 1800 μ sec. in duration. The time constant with which the voltage drops at the front of the gate is about 1 μ sec. This is much slower than would be expected from the circuit design and is due to large stray capacities to the switch and trigger leads.

A similar output with a slightly quicker front is obtained when the circuit is switched to become the multivibrator circuit shown in Figure 4, page 4-4. In this case the anodes and grids are connected in the conventional manner, but the grids are returned to the potentiometer R2. The frequency of oscillation is determined by the time taken for the grid of the tube which is non conducting to rise to the cut-off voltage of 14 volts below the cathode potential. This time is varied by changing the voltage to which the grid tends to charge. The effect of this adjustment is shown in Figure 3, it allows the frequency to be set at 350 c.p.s. permitting a normal tolerance for circuit components.

When V1B commences to conduct the coupling condensers C10 and C8A apply the rapidly rising voltage at the anode of V1A to the grid of V1B. When the grid to cathode potential reaches zero the grid to cathode impedance becomes very small and any further rise in voltage at the anode of V1A is developed across the 20 pf condenser C8A and R19A and the grid is not driven positive.

4.2 Range Calibrator

Figure 5, page 4-6 shows a simplified diagram of the circuit. Its operation is controlled by the gate,



MULTIVIBRATOR GATE GENERATOR

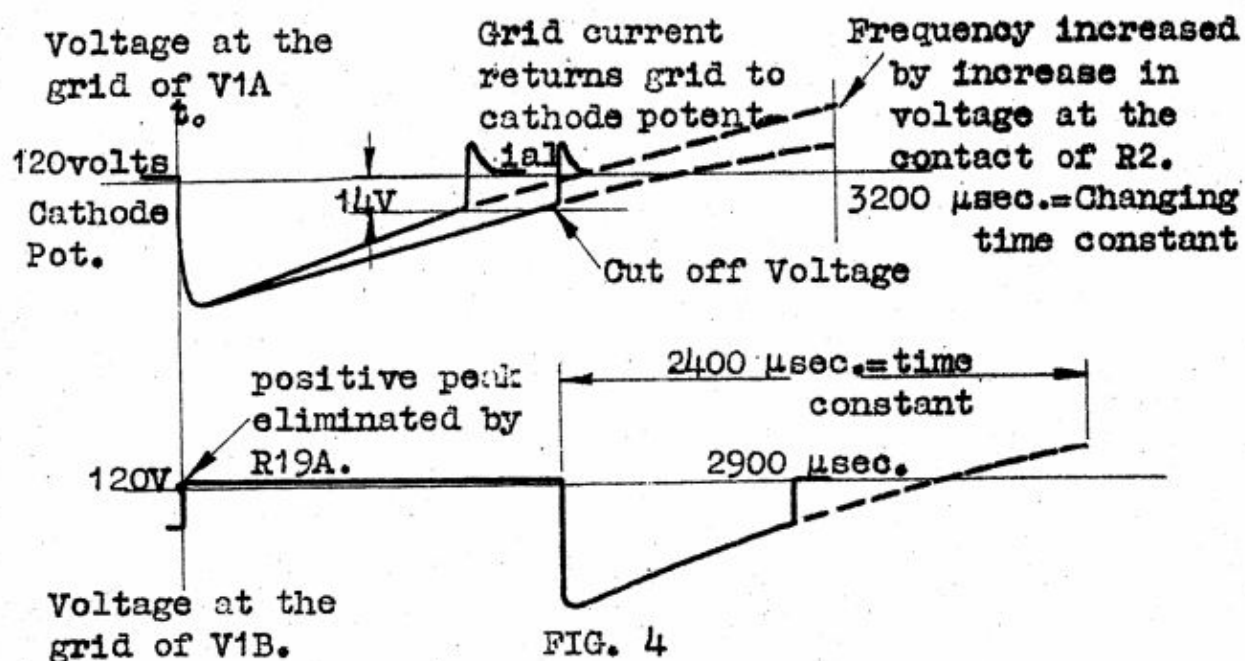


FIG. 4

so that for the duration of the gate it generates the wave forms shown in Figure 5, page 4-6, and in the period between gates it is inoperative.

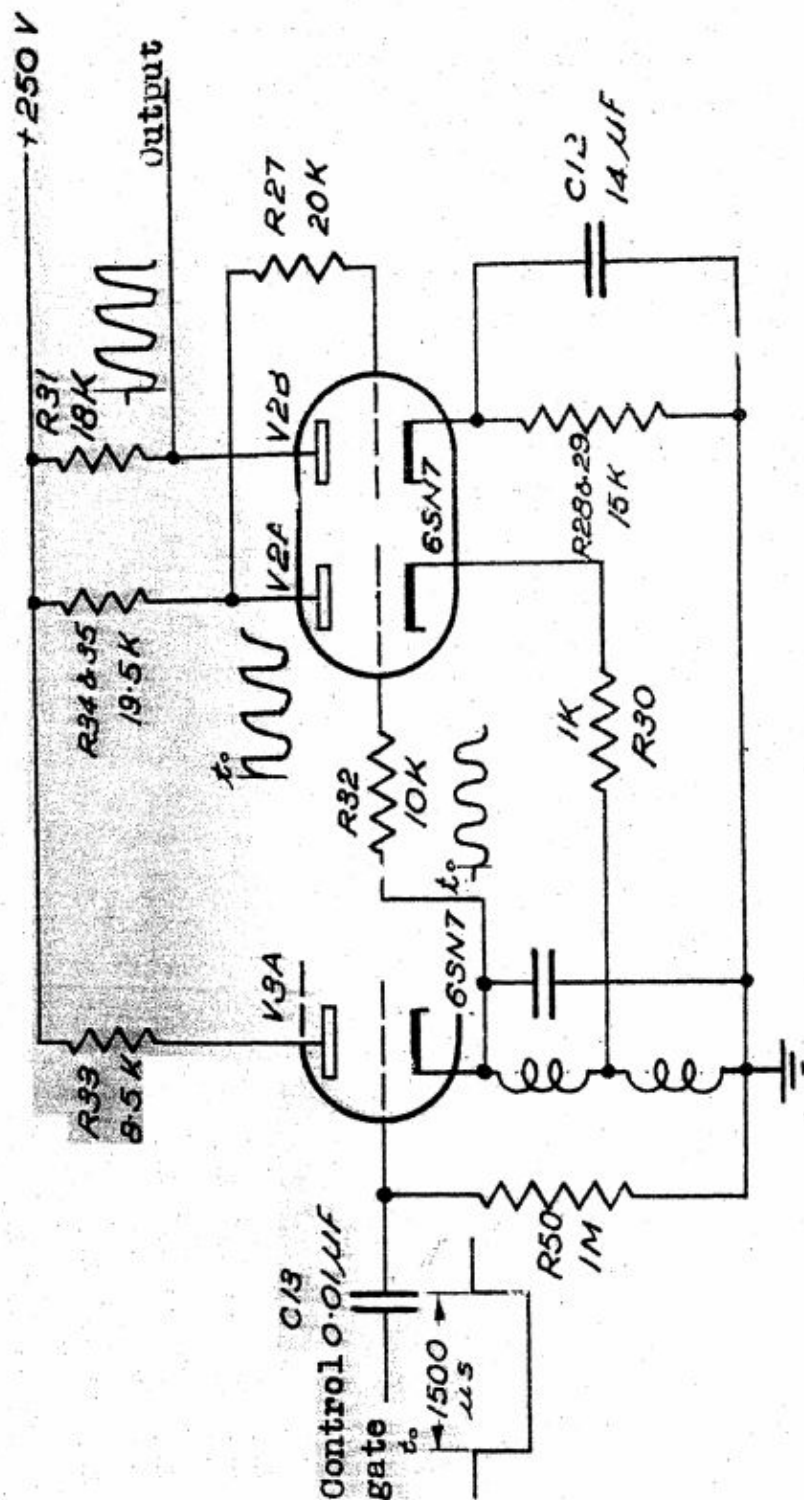
The circuit consists of a Hartley oscillator V2A direct coupled to the amplifier V2B. The tank circuit of the oscillator is one of four L, C. circuits tuned to

161.72 Kc/s. for $\frac{1}{2}$ naut. mile markers
80.86 Kc/s. for 1 naut. mile markers
16.17 Kc/s. for 5 naut. mile markers
and 3.08 Kc/s. for 10 naut. mile markers.

Centre tapped inductors generate a grid to cathode voltage large enough to drive V2A to grid current at the positive peaks and to cut-off at the negative peaks. Grid current through R32 prevents the grid voltage rising above the cathode so that the voltage wave form at the anode of V2B is distorted to a sine wave from which the peaks have been clipped. This is coupled to and overdrives the grid of V2B so that the output wave form at the anode is a square wave consisting of a slow voltage rise as strays on the anode are charged through the 18K Ω load and a rapid voltage fall when V2B starts to conduct. It is this sharp fall of voltage which, differentiated, is used to trigger the modulator.

Between gates the oscillator is rendered inoperative by the low impedance of the cathode circuit of V3A shunted across its tank circuit and the anode current of V3A is limited by the plate load to be equal to the peak current through the coil when oscillating. Thus when the negative gate applied to the grid cuts V3A off, the current in the inductor flows from the condenser, with the result that the oscillator starts at full amplitude and the first marker appears with full amplitude one cycle after the start of the gate.

The values of the anode loads R34 and R35, and R31 and the cathode resistor R28 and R27 are such that the mean voltage at the anode of V2A is about seven volts below the cathode potential of V2B. Under these conditions the



Output at the
anode of V2B
5 mile marker.



RANGE CALIBRATION OSCILLATOR

FIG. 5

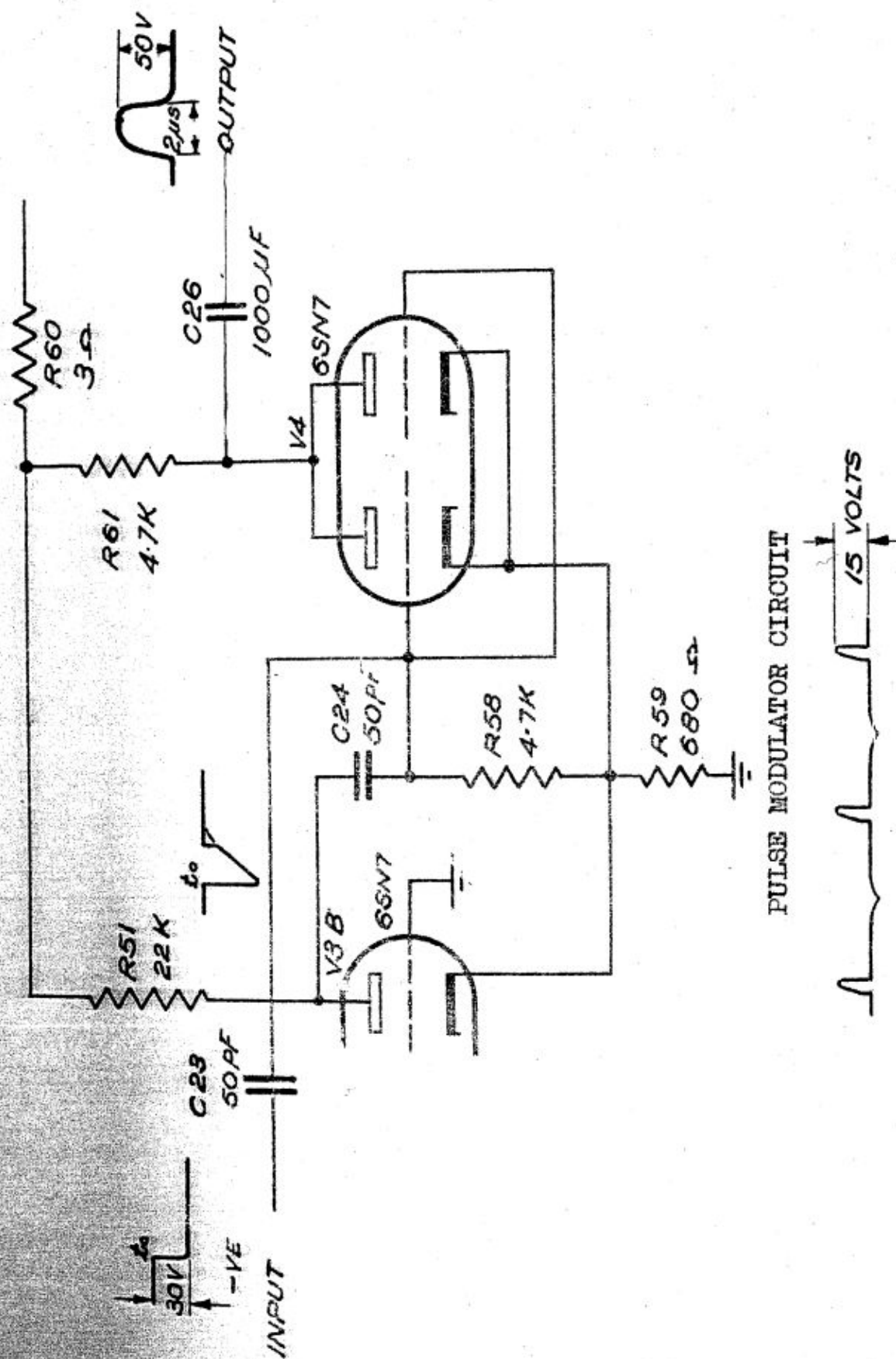
potential across C12 does not tend to change during any part of the cycle of operations and therefore V2B commences to conduct at the same point on each cycle of the L.C. circuit. The interval between markers as therefore exactly equal to the period of the oscillator.

4.3 Pulse Modulator

A sharp drop in potential of 30 volts or greater applied to the input of the modulator (circuit Figure 6, page 4-8) produces an output pulse 2 μ sec. long and 50 volts in amplitude across a 2000 ohm load. Thus if the gate is applied to C23 its front produces one such pulse while if the output of the calibrator is used, a series of pulses spaced at the oscillator period are obtained. These pulses are used to calibrate indicators or to grid modulate the R.F. oscillator.

When the circuit is in its stable condition the grid of V4 is at its cathode potential and its anode current is about 28mA. This current flows through R59 so that the cathode potential of V3B is 20 volts. Since the grid of V3B is connected to ground this tube is non conducting.

When the potential at the input is reduced rapidly C23 carries the grid of V4 down, reducing the anode current and therefore the potential at the cathode of V4 and V3B until V3B starts to conduct. The anode potential of V3B drops and V4 is cut-off allowing its anode, and the output voltage to rise at a rate determined by the capacities to ground charging through R61. The circuit rests with the current through V3B limited by the cathode resistor R59 and the load R51, and the voltage at both anodes steady. However the grid potential of V4 approaches the cathode with a time constant of $\frac{1}{2}$ μ sec. determined by R58 and C23 plus C24. After about $1\frac{3}{4}$ μ sec. V4 starts to conduct causing its cathode potential to rise and V3B is cut off. The anode of V3B is loaded with about 30 pf consisting of C24 and C23 plus strays and therefore rises with a time constant of about 0.6 μ sec. This carries the grid of V4 up and its anode falls terminating the pulse with a tail about $\frac{1}{2}$ μ sec. long.



Video Range Markers, 5 mile spacing

FIG. 6

4.4 Radio Frequency Oscillator U857

Signal Generator Assembly, Figure 22, page 6-12.

The radio frequency oscillator covers the frequency range 170 - 240 Mc/s., and operates either C.W., or pulsed. A type 6J6 double triode is used as the oscillator tube, in a push-pull circuit, with a tuning circuit between anodes, and with cross connected feedback condensers. The grid returns are made through two chokes and a common grid leak. A built in attenuator and the complete shielding of this unit makes it possible to use it as a signal generator.

The tuning circuit consists of parallel rod lechers with a split-stator tuning condenser. The lechers are at ground potential for D.C., and are connected to the anodes of the 6J6 through condensers, while the D.C. connections to the anodes are made by insulated wires run through the lecher tubes.

It was found experimentally that the oscillator functions most satisfactorily when the lechers are earthed by a lead from the top end of the shorting bar to an adjacent point on the case. This is achieved by clamping the earth lead under the cover of the case.

The frequency range covered by the condenser tuning can be varied by changing the position of the shorting bar. In this way frequencies from 140 Mc/s. to 250 Mc/s. may be obtained.

The grids are connected together by two chokes (L16 and L17), and a connection from the junction of the chokes is brought outside the shield box. This lead is connected to the pulse modulator through a condenser (C26) and switch (S3B), and to ground or minus 20 volts through the 1800 ohm grid leak resistor (R63 and switch S30). When S3 is in the C.W. position, the modulator is disconnected and the grid returned to ground. In this condition, the oscillator operates continuously. With the switch set to TRIGD, the modulator is connected, and the grid is held biased beyond cut-off. The modulator applies rectangular

positive pulses 2.2 μ sec. in length which overcome the 20 volts of bias and produce pulses of oscillation, 1.5 μ sec. in length, with a starting delay of about 0.5 μ sec. Figure 7, page 4-11 shows the shape of the modulating pulse and the envelope of the R.F. pulse respectively.

Three outputs from the oscillator are provided, namely, low level output through an attenuator, high level output, and output to the wavemeter.

The attenuator consists of a $\frac{1}{2}$ " inside diameter tube, fitted with a faraday screen, mounted close to the shorting bar of the lechers. A sliding piece inside the tube carries a coupling loop and 72 ohm terminating resistor (R72). The output is brought from this slide by way of a flexible coaxial cable to the front panel. The attenuator is driven from the front panel by a rack and pinion, and a dial calibrated in decibels is fitted. The rate of attenuation is 64.0 db. per inch. The zero of the scale is taken at 0.1 volts R.M.S. into 72 ohms (140 μ watts), the maximum output being 10 db. less than this.

The high level output connector is coupled fairly tightly to the lecher circuit, and feeds an output of the order of 1.5 volts into a 72 ohm load. This output is used when the test set is operating as a transmitter at a power higher than that available through the attenuator. Such an arrangement would be required for aerial diagram measurements.

The third output circuit is also coupled to the lechers and feeds a small amount of energy to the wavemeter.

The amplitude of oscillation is monitored by V10, a type VR92 (EA50) diode. A small coupling loop attached to the anode of this tube is electromagnetically coupled to the lechers at the shorting bar. As the coupling to the attenuator is also electromagnetic, and from the same part of the oscillator circuit, the output voltage of the diode rectifier is proportional to the electromagnetic field inside the attenuator tube.

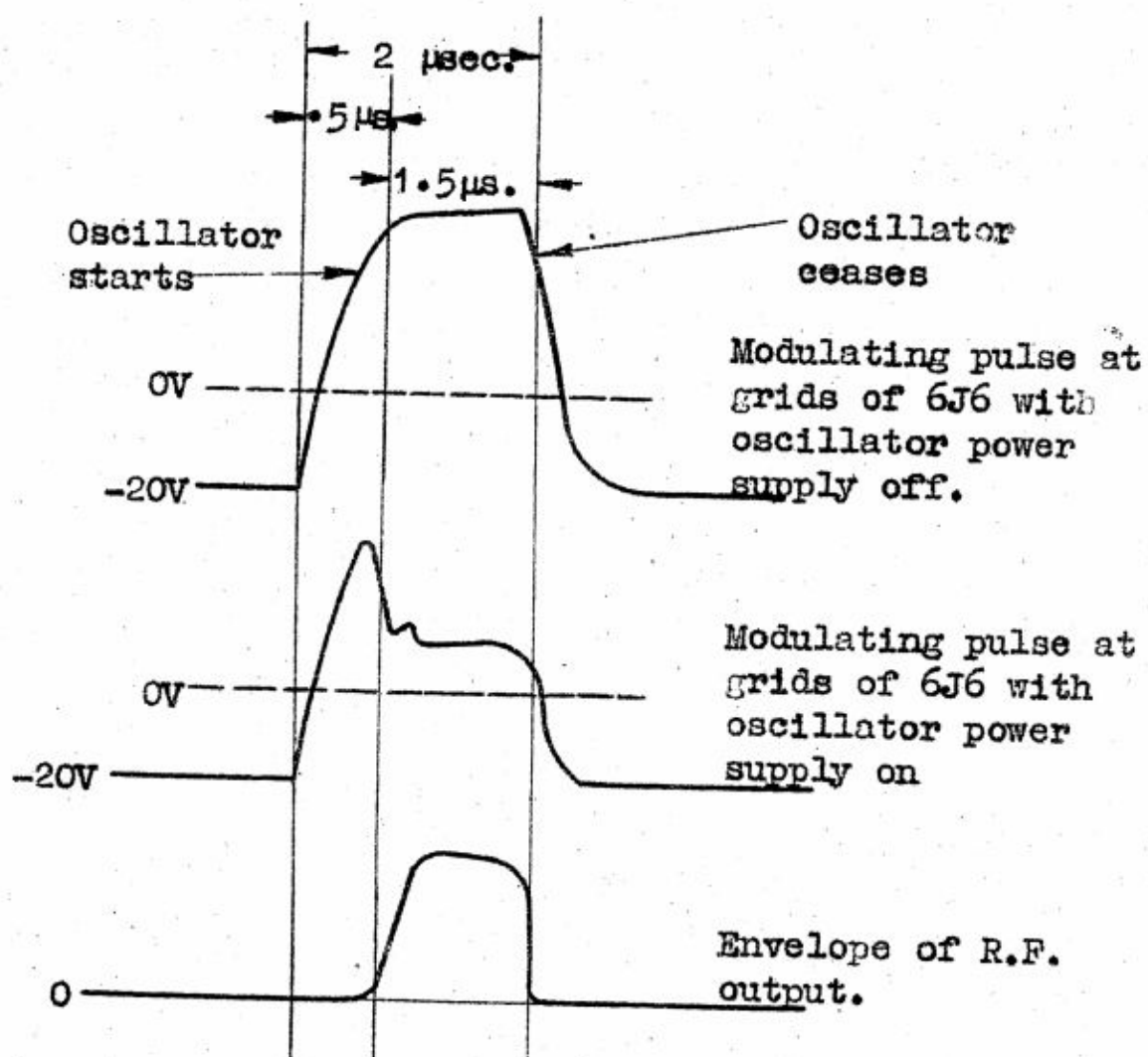


FIG. 7

If V10 is in the R.F. field the current through it is effected by an amount which depends upon the frequency of the field. This would mean that for a constant monitor reading the output of the attenuator would depend upon the frequency thereby rendering the attenuator calibration meaningless. To overcome this a small shield is placed around the EA50.

The diode load is one megohm and therefore the monitor indicates the peak voltage of the R.F. output for C.W. operation, 0.4 db. down from peak when the oscillator is generating R.F. marker pulses at 1 mile spacing and $7\frac{1}{2}$ db. down when generating a single pulse with a repetition frequency of 350 c.p.s. For this reason it is stated in the operating instruction § 3.6.2 that the amplitude for pulsed operation must be set with the range calibrator switched to 1 mile markers. The peak amplitude is then about the same for all repetition rates.

All connections to the oscillator are filtered, the filters consisting of 100 pf mica condensers which resonate with their leads at about 200 Mc/s. to give a low impedance shunt to ground and series chokes which with their own stray capacities form high impedance circuits in series with the leads. However in the case of the grid lead it is impossible to carry out such complete filtering. Here it is necessary to keep the capacity to ground as low as possible to avoid distorting the modulator wave form. However in this case the two 10 pf condensers and three chokes used give sufficient filtering.

The tuning condenser shaft, of insulating material, comes out of the shield through a long sleeve. The diameter of this sleeve is very much less than that required for efficient propagation, so that energy which tends to leak outwards is very rapidly attenuated.

The tuning condenser (90° rotation) is geared to the dial, which has a travel of 600° and this in turn is driven through a ball type epicyclic drive by the tuning knob.

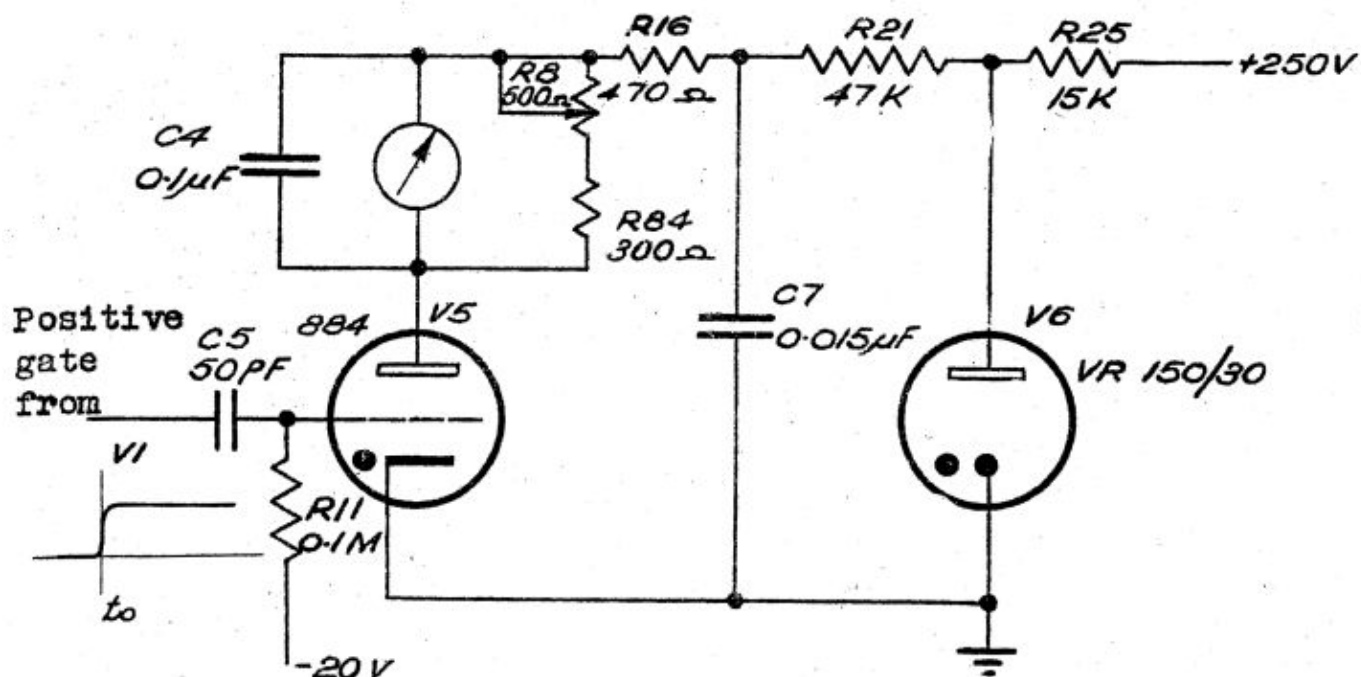
The amplitude of oscillation is controlled by the voltage of the anode supply which is drawn from the cathode of V4A. The voltage at the grid and therefore at the cathode of this tube is controlled by the potentiometer R66 and is therefore independent of the current drawn, with the result that the anode voltage of the oscillator is unchanged when switching from C.W. to pulsed operation.

Removal of the cover, item No.3, Figure 22, page 6-12 allows access to the shorting bar and also allows the replacement of either valve. If however, more extensive maintenance or modifications are required the cover, item No. 2 is also removed and the oscillator withdrawn from the case by slackening the set screws in the drive, item 41, and removing the screws which secure the chassis and filter panel to the case as shown on page 6-12 and 15.

4.5 The P.R.F. Meter

The P.R.F. meter reads repetition frequencies of 0 to 500 c.p.s. on a special scale of the meter. The principle of operation is described in § 2.5 where it is pointed out that the scale is contracted from linear by 5% at 500 c.p.s. The reason for this non linearity is explained by the way the circuit shown in Figure 8, page 4-14 operates.

The voltage regulator V6 draws sufficient current through R25 to maintain its anode at 150 volts. C7 therefore charges through R21 to 150 volts and the 20 volts of bias on the grid of the thyatron V5 prevents it conducting. The positive gate from the generator V1 is differentiated by C5 and R11 which together have a time constant of 5 μ sec. so that at the commencement of each gate a positive pip is applied to the grid of V5. V5 conducts and the current, limited by R16, flows through the meter and discharges C7 with a time constant of 9 μ sec. therefore taking about 20 μ sec. to reach 15 volts. During this period the grid has returned to -20 volts so that the thyatron deionises and C7 charges to 150 volts with a time constant of 700 μ sec. (C7 x R21).



P.R.F. METER

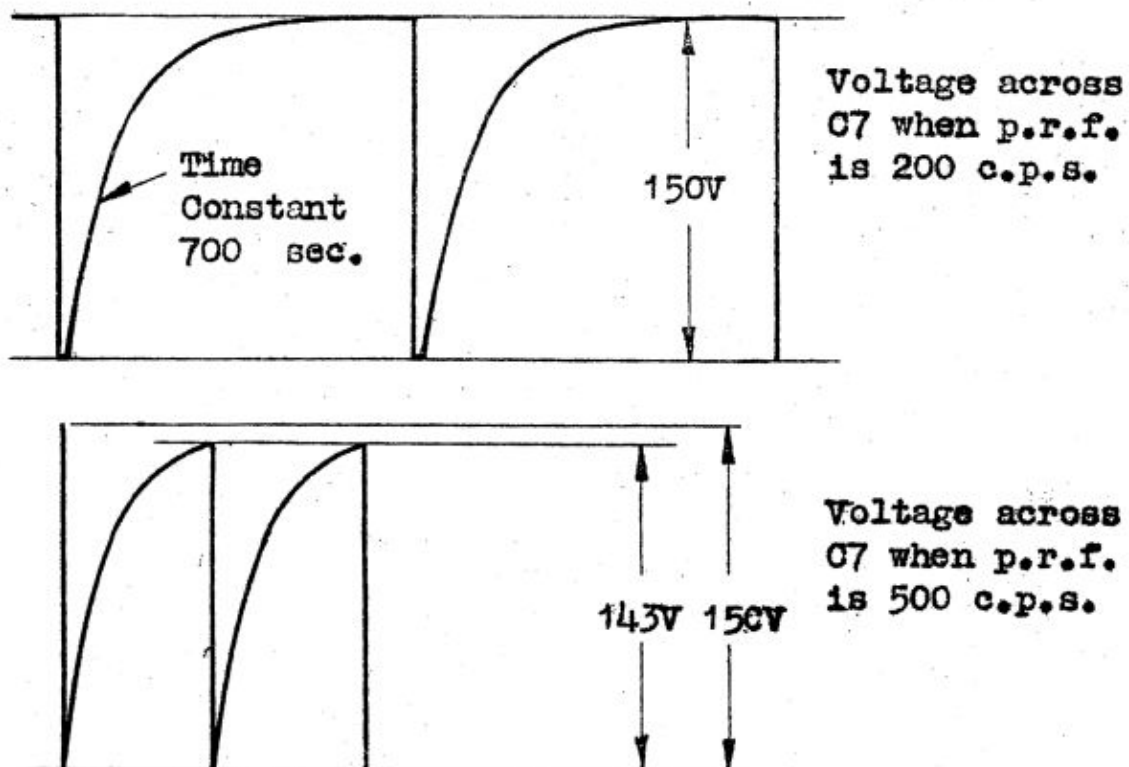


FIG. 8

The gate generator may be triggered by a video pulse or a pulse of R.F. or the test set may be self timed. In each case every gate causes C7 to discharge from 150 to 15 volts through the meter so that the meter reading is proportional to the repetition frequency.

When the P.R.F. is 500 c.p.s. the period between pulses, during which C7 has to charge, is only 2000 μ sec. or three times the charging time constant. In this time C7 can only charge to 95% of the 150 volts so that the current through the meter is 5% less than if C7 had charged completely. The meter scale from 300 c.p.s. to 500 c.p.s. is contracted to correct for this error.

To allow calibration of the meter to compensate for variations in circuit components a potentiometer R8 in series with R8A is connected across the meter, while the condenser C4 also connected across the meter reduces the peak current through it.

To conserve power, the high tension voltage is applied to the P.R.F. meter only when the meter switch is in the P.R.F. position.

4.6 Wavemeter, U856.

Figure 19, page 6-9 and the photographs on pages 6-10 and 6-11 give the complete details of the construction of this unit. Electrically it consists of a length of coaxial line slightly shorter than a quarter wavelength at 250 Mc/s., one end is shorted and the other is shunted by the tuning condenser. This condenser is driven by a shaft running through the inner conductor to the shorted end where a worm drive is mounted. The trimmer C63 is adjusted so that the circuit tunes to 250 Mc/s. when the tuning condenser C62 is at a minimum. This provides a tuning range of 150 Mc/s. to 250 Mc/s. with a setting accuracy of ± 20 Mc/s.

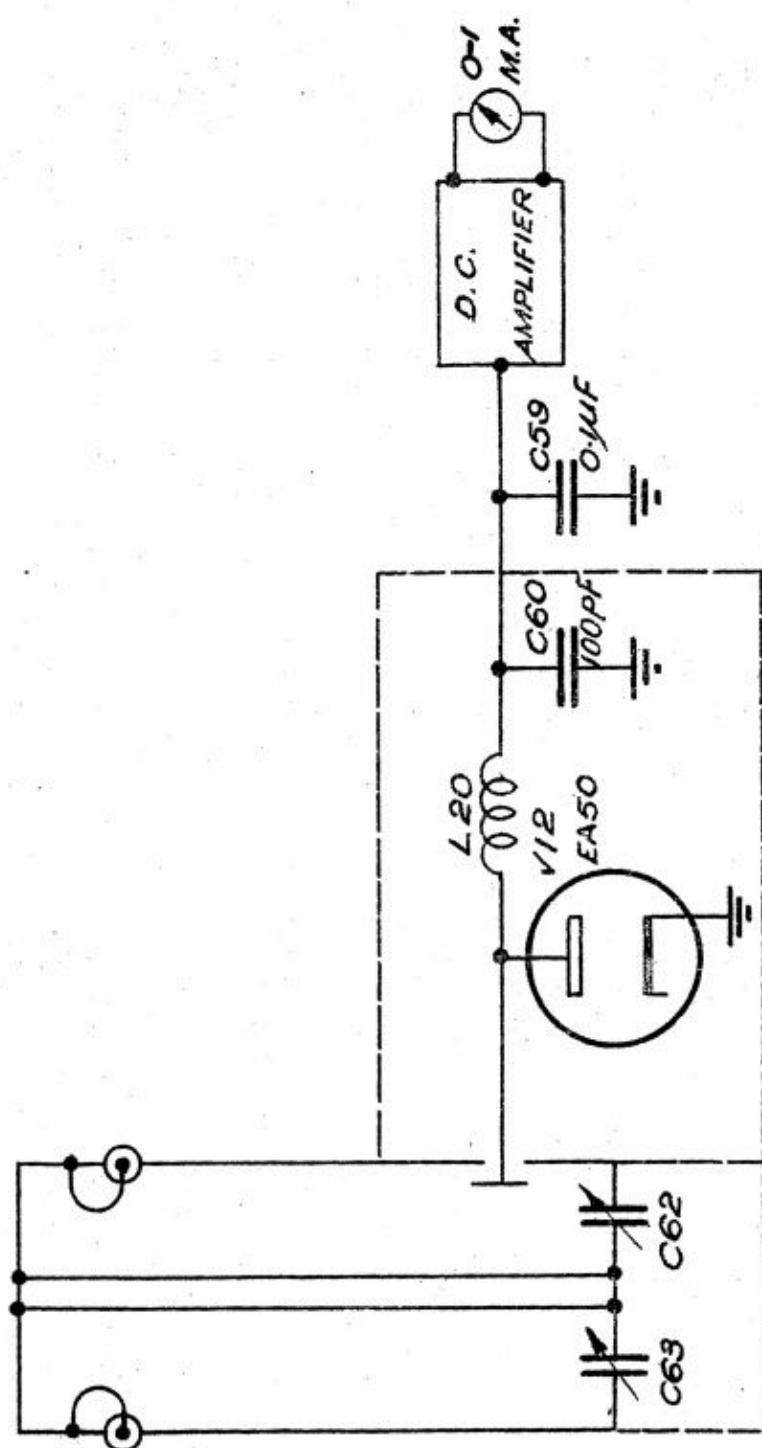
Energy may be coupled to the line by one of two loops linking the magnetic field at the closed end. These are loosely coupled so that the tuning of circuit is independent of the impedance connected to them.

When the circuit is tuned to the frequency of the applied signal energy is delivered to it and an increased voltage is developed across the open end of the line. The diagram of Figure 9, page 4-17 represents the complete circuit and shows how the resonance is detected by measuring this voltage by means of the D.C. amplifier and meter. The VTVM SENSITIVITY control makes it possible to obtain a satisfactory meter reading with input voltages of from 0.2 volts to 200 volts.

If a fault is suspected in the detector circuit a simple check can be made by removing the R.F. input, setting VTVM SENSITIVITY to range No. 1, shorting the output lead from the detector shield to ground, and then set the meter to zero by means of VTVM ZERO. When the short is removed the meter should read about 0.1 to 0.3 mA due to the emission voltage of the diode. If this deflection does not occur, check to see that the output lead is not permanently shorted to ground and then try replacing the diode.

To remove the diode, unsolder the leads from the lugs on the cap, item 13 of the drawing on page 6-9, and take the cap off the diode housing, carrying with it the diode and the other circuit components. The coupling probe, item 12, can then be removed from the anode and the tube withdrawn from the socket. Before replacing the cap and diode remove the end cover, item 11, from the wavemeter and take care while replacing the cap that the coupling probe and polystyrene bush on the anode enter the hole in the wavemeter. If the cover is forced on while the bush is riding on the edge of this hole the diode envelope will be cracked.

4.6.1 The wavemeter was calibrated by coupling the maximum output (about 0.2 volts) from a signal generator into the wavemeter and a crystal controlled heterodyne type frequency meter so that the frequency could be set to $\pm \frac{1}{200}$ Mc/s. The calibration accuracy of the first model was maintained at $\pm \frac{1}{20}$ Mc/s. over a period of three months although the dial had a total backlash of $\frac{1}{20}$ Mc/s. This accuracy of reading is not provided by the calibration curves and so



WAVEMETER AND TUNING INDICATOR

FIG. 9

a series of spot readings at the Eureka frequencies are provided (see Figure 27, page 6-17).

4.7 Diode Voltmeter, U858

The electrical operation of this unit is described in § 2.7 and the mechanical design is shown by Figure 14 and the photographs on pages 6-4 to 6-8.

Figure 17 (page 6-7) shows the outer shield of the unit being removed to allow access to the circuit components. However, when replacing any component it is convenient to break the unit into the two sub assemblies of Figure 18.8 Mounted on the inside of the anode end-plate is the terminating resistor R73. This resistor is enclosed in a small metal tube which makes the unit a closer match to the cable over a wide frequency range.

In § 2.7 it was pointed out that at frequencies above 200 Mc/s! the voltage developed across the interelectrode space of the diode was greater than the voltage at the terminating resistor. The magnitude of this resonant voltage rise was measured by comparing the output of the diode head with that of a similar circuit employing a CV58 rectifier. Checks were made to show that these two circuits loaded the R.F. generator by the same amount so that the input to each was identical. At 176 Mc/s. the outputs were equal but as the frequency increased the output from the diode head exceeded that from the CV58. At 210 Mc/s. this excess was 20% and at 235 Mc/s. 40%. The calibration curve of Figure 23, page 6-18 is drawn for the combination of the diode head plus D.C. amplifier. It was determined by applying known voltages to the amplifier input and observing the meter reading. These readings were plotted against $\frac{1}{1.20}$ of the applied voltage so that the calibration curves are correct for R.F. voltage measurements at 210 Mc/s. At 176 Mc/s. this calibration is $1\frac{1}{2}$ db. low and at 235 Mc/s. it is $1\frac{1}{2}$ db. high. A correction factor for each frequency is obtained from the curve of Figure 29, page 6-19.

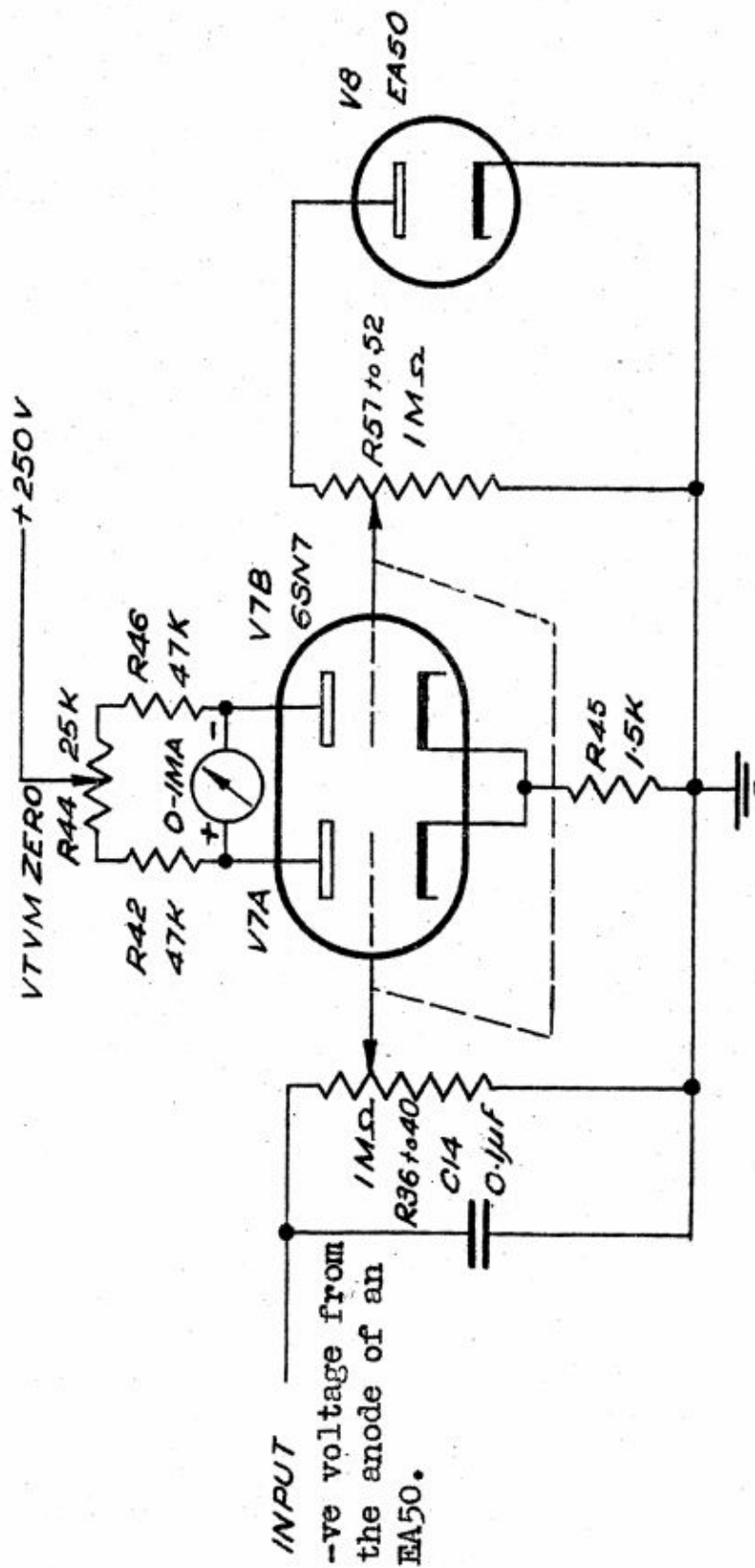
4.8 D.C. Amplifier

When rectifying pulse modulated R.F. voltages it

is impossible to obtain a mean rectified current large enough to be measured conveniently. If however the rectifier load is made very large and by-passed, the voltage developed is close to the peak voltage of the R.F. The input attenuator of the circuit of Figure 10, page 4-20 is the load for the wavemeter detector, signal generator monitor and the diode head. This circuit gives a small power gain but its main function is to operate the 0-1 mA meter and provide a high impedance input.

When no R.F. is applied to the anode of the rectifier both grids of V7 are held at a small negative potential with respect to earth by the voltage of emission of the diodes connected to them, and R44 is adjusted until no current flows through the meter. When the voltage at the grid of V7A falls its anode current is reduced causing the cathode potential to fall and the current of V7B to increase. This transfer of current from V7A to V7B produces a current through the meter which is proportional to the voltage applied to the grid of V7A and is equal to 1 mA for $1\frac{1}{2}$ volts. The maximum attenuation of the input voltage is 200:1 giving voltage ranges up to 300 volts.

The emission voltage of the two EA50's may not be equal but R44 allows the meter to be set to zero. However when the range switch is operated the difference in potential between the two grids is changed and the meter must be set to zero again. The magnitude of this adjustment is very small compared with that required if V8 is omitted and no attempt is made to balance the standing currents. When renewing one of the diodes it is necessary to select a replacement with a suitable emission voltage. All EA50's are of two types, in the first the standing current through a 100Ω meter is between 0.08 mA and 0.2 mA while in the second it is between 0.5 mA and 1.0 mA and it is desirable that the four valves V8, 10, 11, and 12 all be of the same type. To classify a new tube set the meter switch to TERMLS and connect the anode of the tube to the NEG. terminal and the cathode to POS. Apply 6.3 volts to the heater and compare the standing current with that of V8. It will be found that about half the diodes tested



D.C. AMPLIFIER CIRCUIT

FIG. 10

will fall into each class so that a tube of the required type will be obtained by testing a maximum of three or four.

The heaters of the valves in the test set are arranged in groups of four in series so that care must be taken when extra heater supply is being obtained from the circuit.

4.9 Power Supply

The circuit of this unit U859 is shown in Figure 11, page 6-1, and the power requirements, the supplies provided, the circuit operation, and shielding to prevent R.F. interference, are all described in § 2.10. Two further points about the circuit remain.

It is usual to connect the timing condensers of a vibrator power supply across the secondary winding of the transformer. In such a circuit the leakage inductance of the transformer resonated with the timing condensers at 2000 c.p.s. so that when the power supply was operated from the 80 volts, 2000 c.p.s. mains a very large voltage was developed across the condensers and at the output. Even at frequencies below resonance there was severe capacitative loading of the transformer, and the initial current surge when switching on was exceedingly high. For these reasons a large condenser (C99, 4 μ F) in the primary circuit is used. The connections to P10 are then such that C99 is not in circuit for A.C. operation.

The heaters of V15 and the C.R.T. are at a potential of about 700 volts from ground and therefore have to be supplied from a special winding on the transformer even when the set is operated from D.C. It is required that the D.C. output from the power supply be the same, and that the heaters of V15 and the C.R.T. receive the same power, on both A.C. and vibrator operation, but the D.C. output is proportional to the peak of the voltage at the secondary of the transformer while the heating is proportional to the

R.M.S. of this voltage. Also, for a sine wave the peak voltage is 1.4 times the R.M.S. while for a square wave the peak is equal to the R.M.S. voltage. Thus if the D.C. output is made equal for both cases the cathodes will be overheated on vibrator or under heated on the sine wave supply. Vibrator circuits which generate sine waves have been developed but they require that the power transformer have a large leakage inductance, which would interfere with operation on 2000 c.p.s. mains, or a separate inductor which would involve extra weight and space. In the circuit used the vibrator does not generate an exact square wave and the R.M.S. voltage is therefore less than the peak, also when operating from A.C. mains the wave form is slightly squared by the transformer with the result that a workable compromise between constant D.C. output and correct cathode heating is possible.

4.10 Metering

The units described above are interconnected according to the schematic diagram of Figure 1 to form the circuit shown in Figure 11, (page 6-1). This circuit provides for the meter to be used to check the current to each unit. When the set is functioning correctly the readings should be about the same as those in the

5. PRODUCTION MODELS

5.1 Test Unit and Oscilloscope

Test Unit and Oscilloscope are being produced by the Gramophone Co. Ltd. and incorporate many improvements in design which make them lighter, easier to service and to use.

5.1.1 The Production Diode Head

The components of this unit are slightly rearranged to enable the valve to be replaced without removing the end plates. It has also been possible to eliminate the resonance which occurred in the prototypes so that the correction curve of Figure 29 will not be required.

5.1.2 The D.C. Amplifier

A meter shunt has been incorporated in the D.C. amplifier circuit to make the voltage required for full scale meter reading a neat value and so do away with the calibration curves provided with the first sets.

It is therefore possible to read the voltage at all frequencies directly from the meter. This convenience is gained however at a slight loss in accuracy of measurement.

5.1.3 The Worm Drive on the Wavemeter has been greatly improved by using ball bearings and a ball thrust race combined with spring meshing of the gears. The backlash is less than $\frac{1}{20}$ Mc/s. and the control operates with a velvet smoothness.

5.2 Production Aerial

The aerials are being produced by Precision Engineering Co. Pty. Ltd. and will consist of the tripod and radiating assembly shown in Figure 32 page 6-22. The radiator can be mounted to give either vertical or horizontal polarization and it has the same gain and polar diagram as a dipole. In place of the second dipole supplied with the prototype equipments a single rod radiator mounting directly on the set is provided.

.....*V.D. Burgmann*.....

V.D. Burgmann

(HEAD OF GROUP)

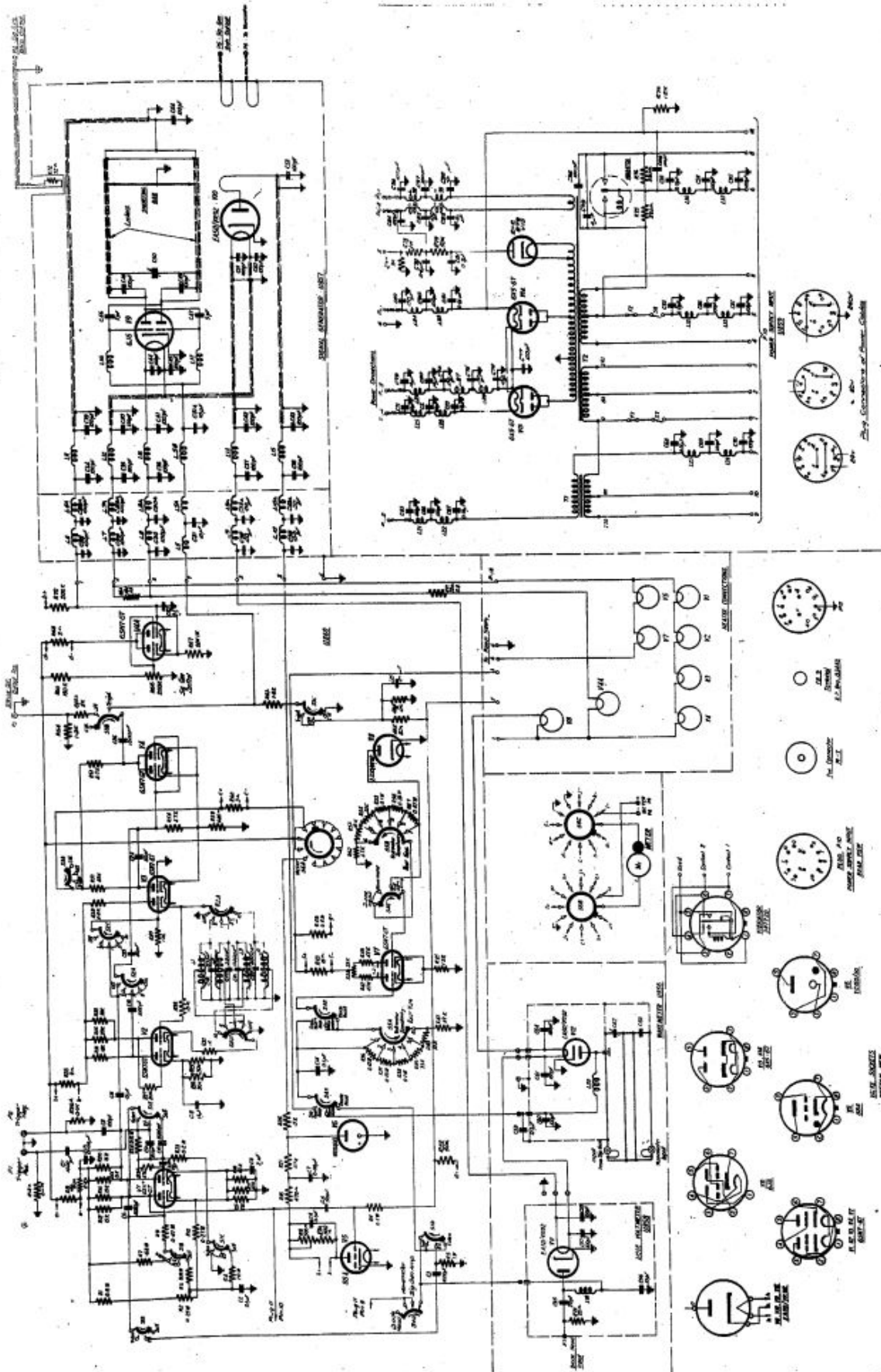


Figure 11. CIRCUIT OF TEST UNIT

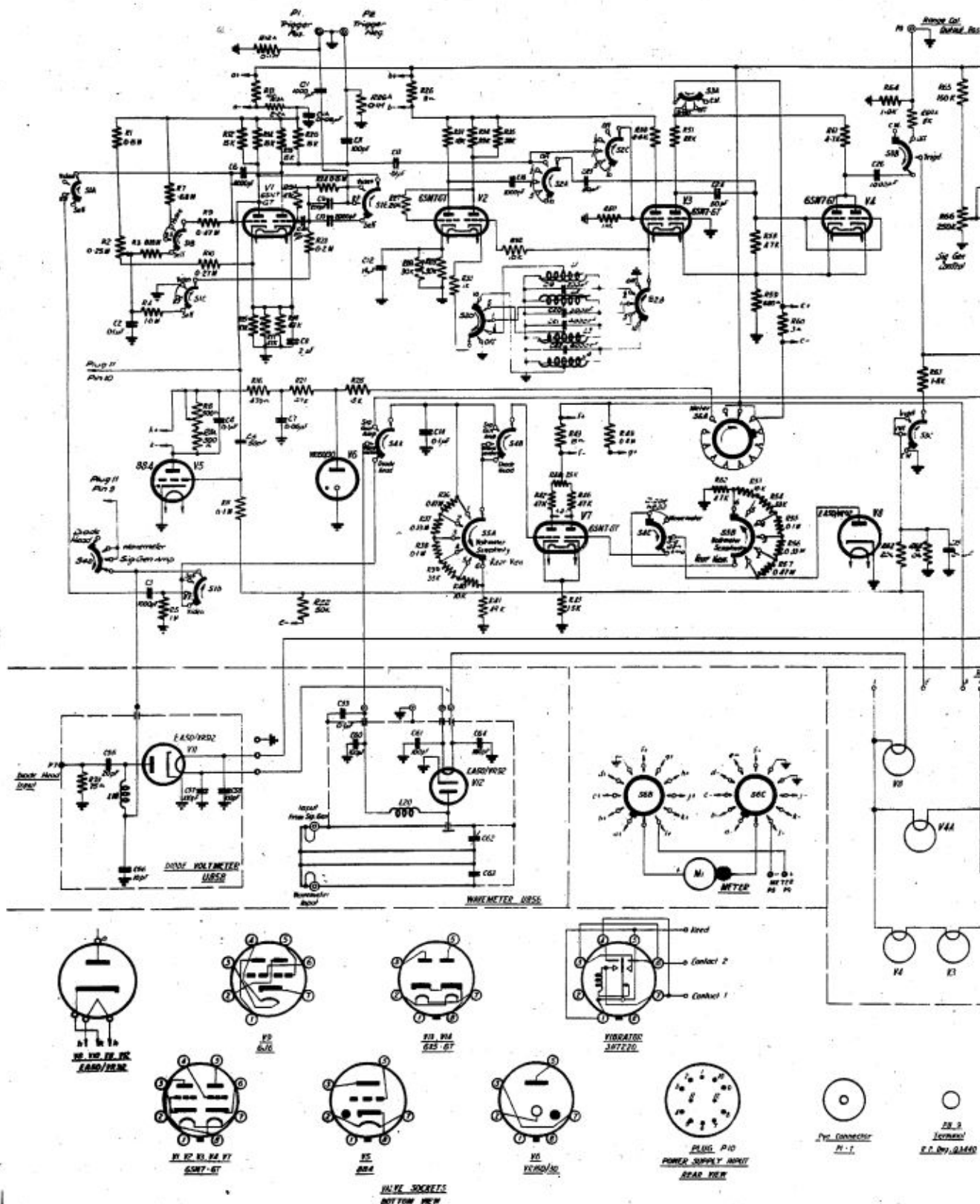


Figure 11. CIRCUIT OF TES

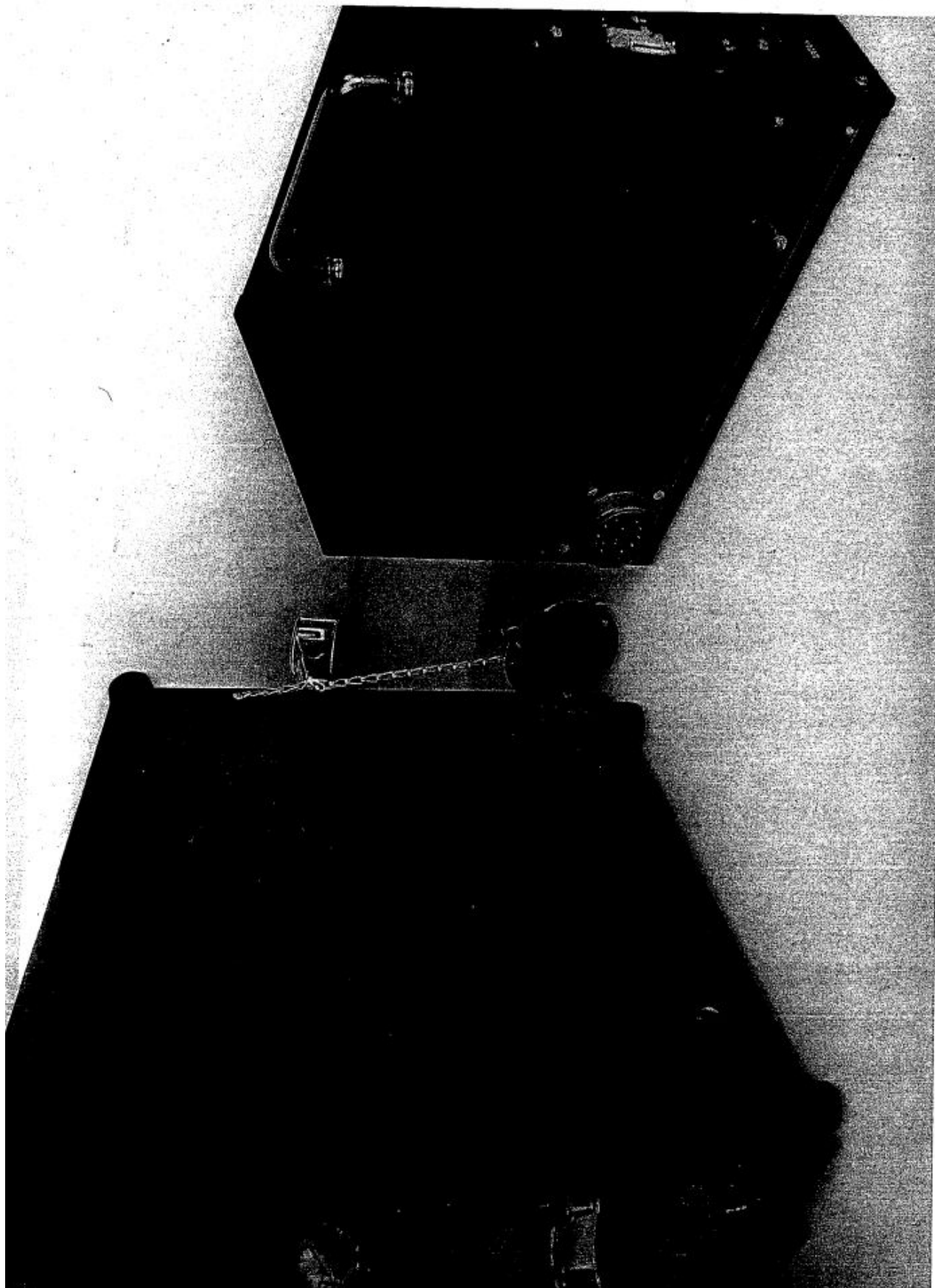
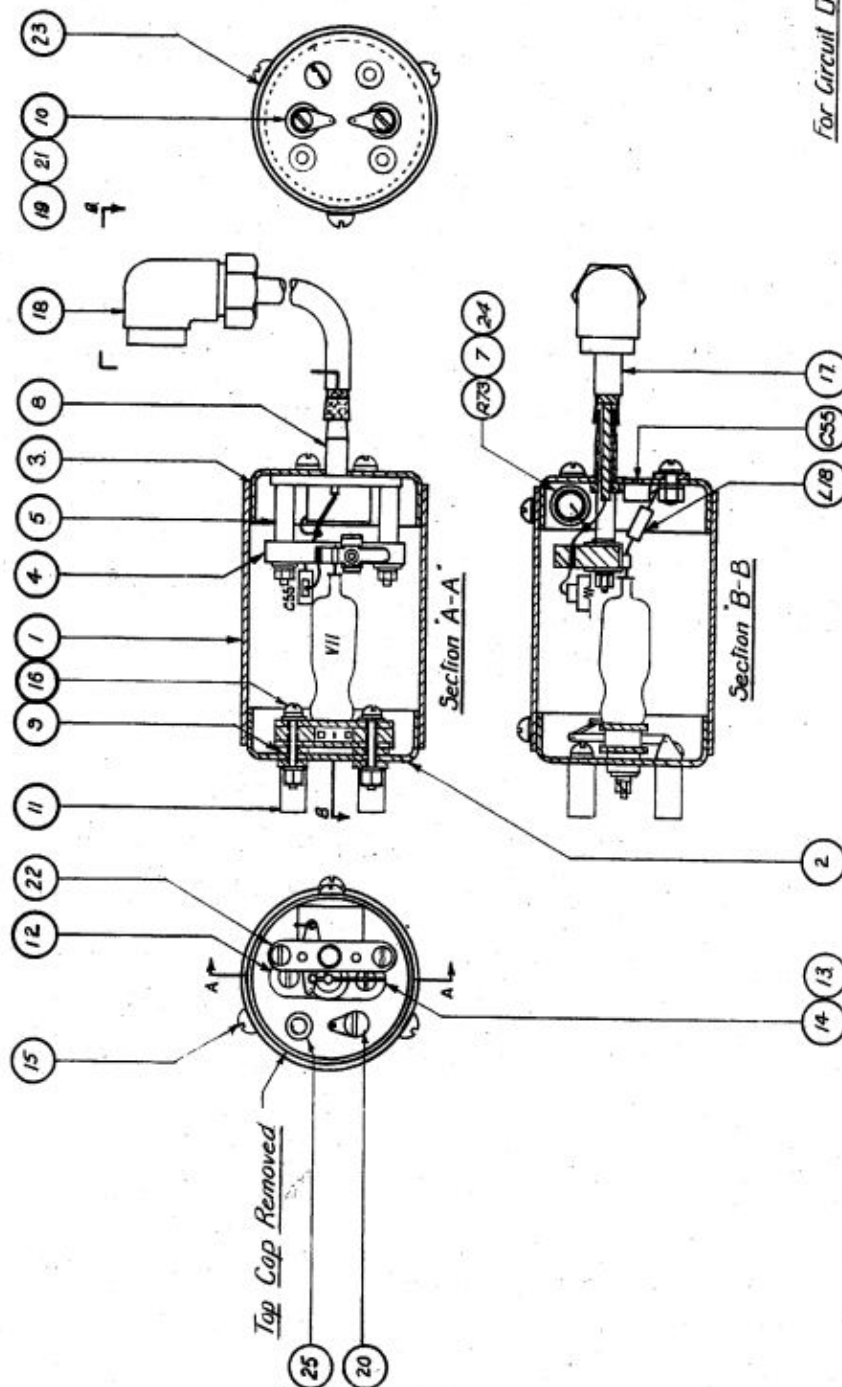


Figure 13 TEST UNIT TO C.R.O. CONNECTOR



For Circuit Diagram See DWG PB#44
For Component Parts See List N° 8446

Figure 14. DIODE HEAD

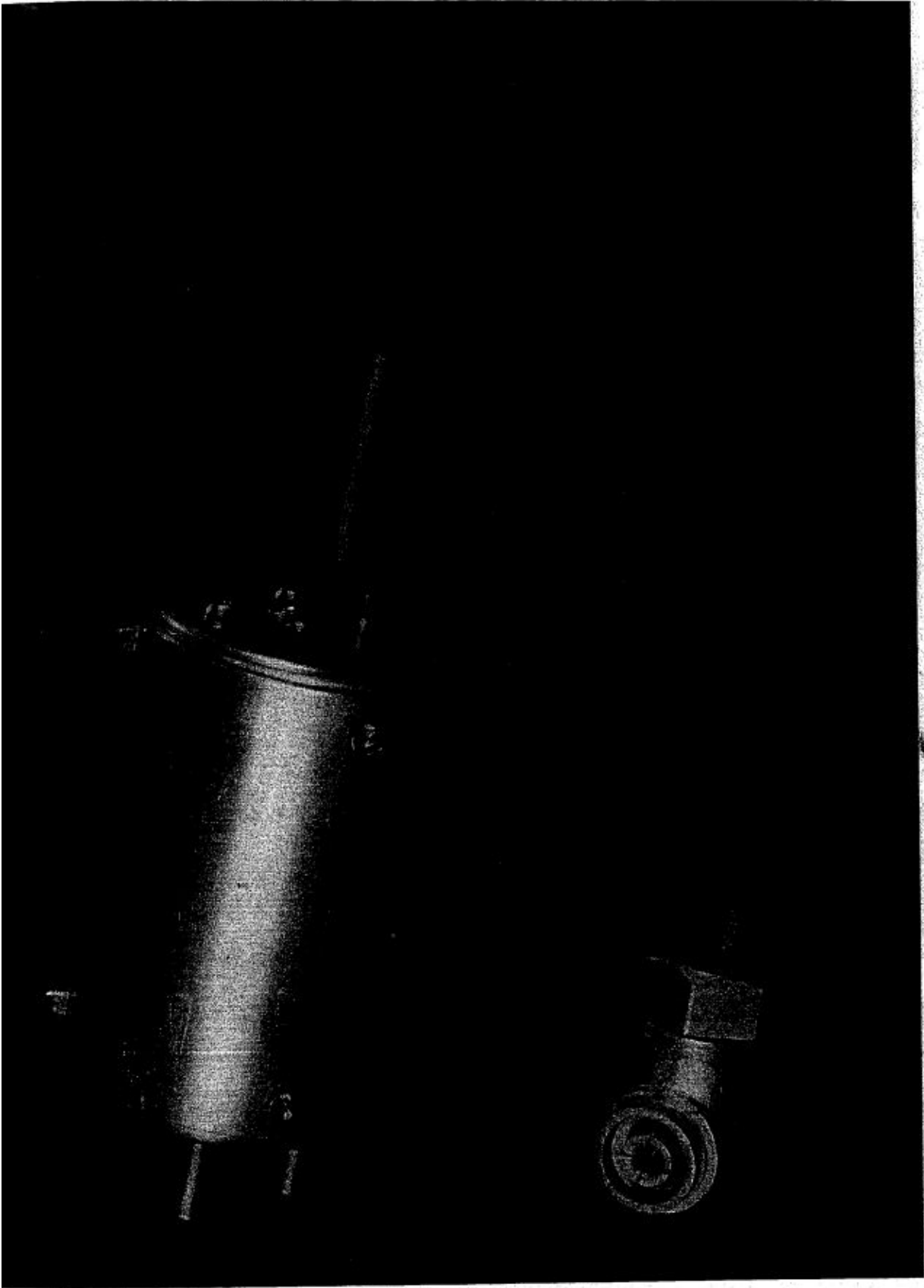


Figure 15 EXTERNAL VIEW OF DIODE HEAD

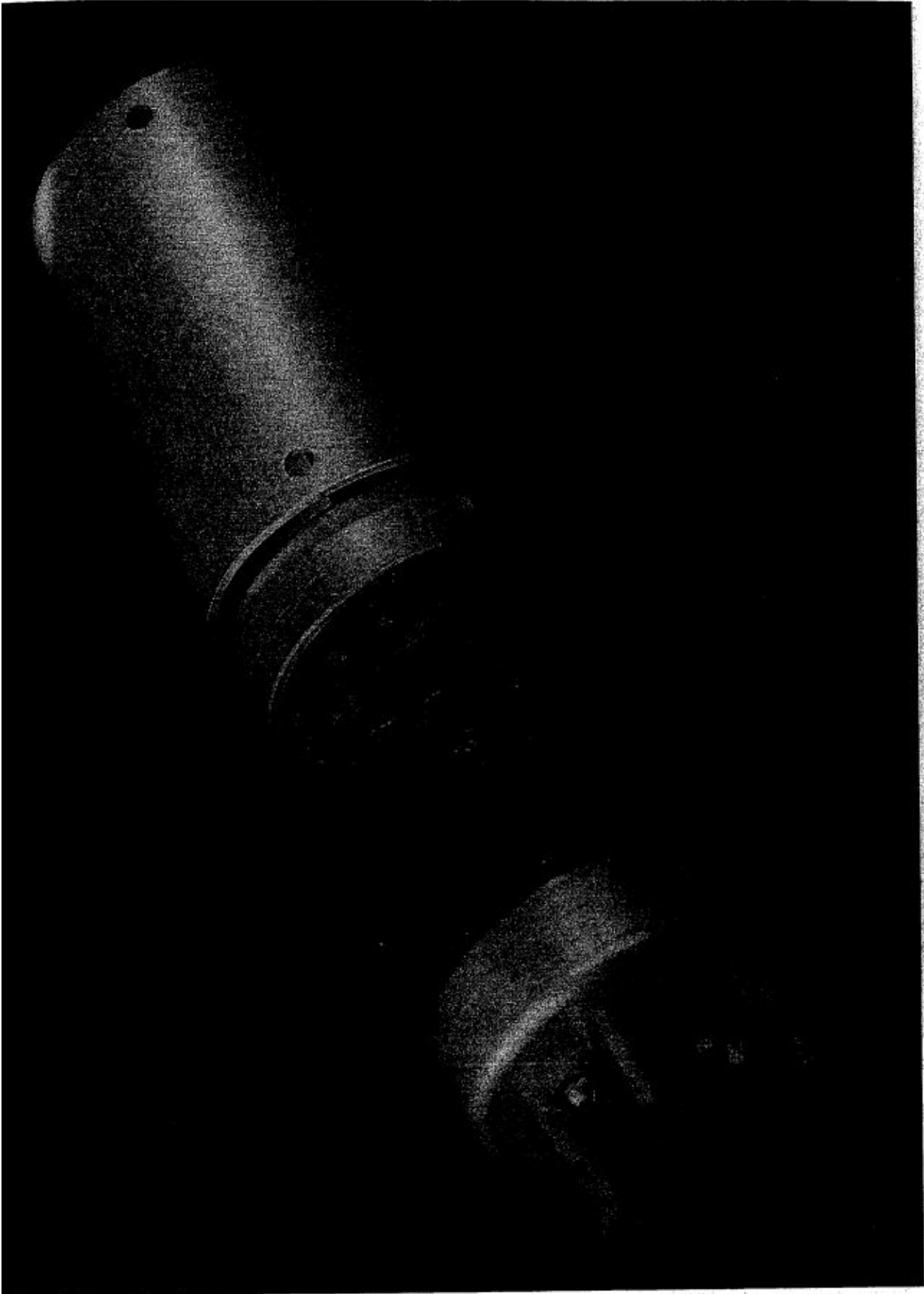


Figure 16 INTERNAL VIEW OF DIODE HEAD

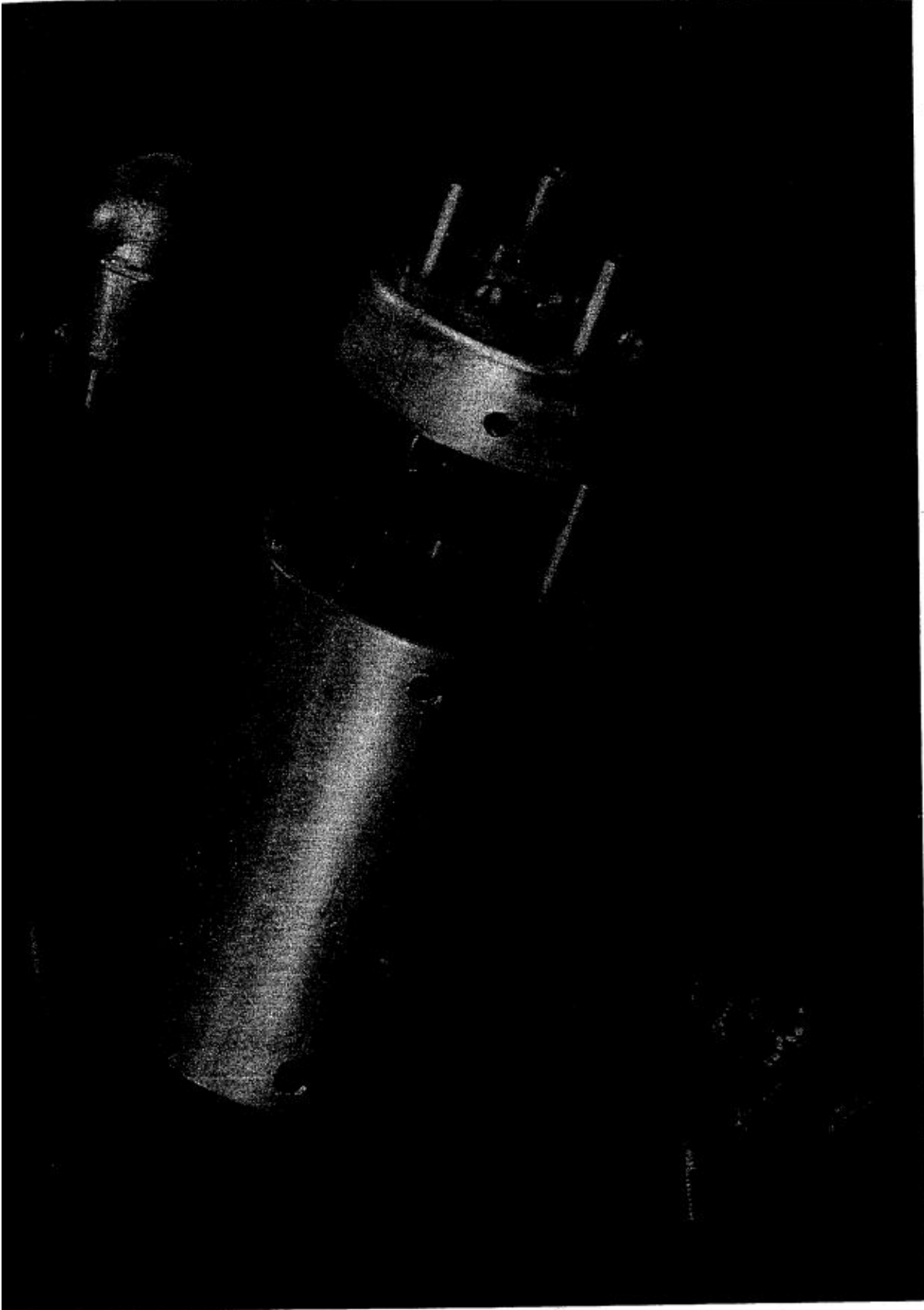


Figure 17 DISMANTLING THE DIODE HEAD

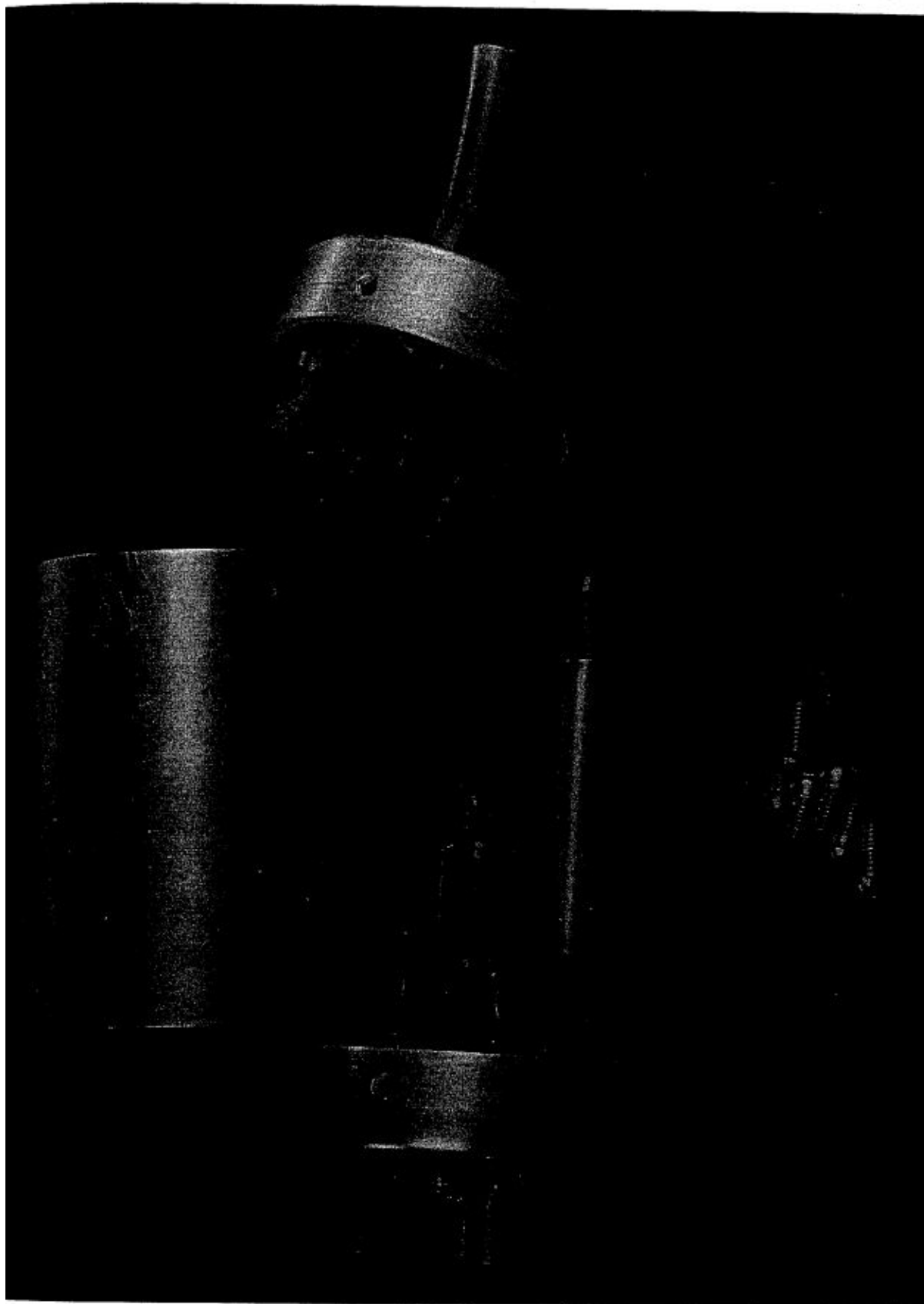


Figure 18 COMPONENTS OF THE DIODE HEAD



Figure 20. EXTERNAL VIEW OF WAVE METER

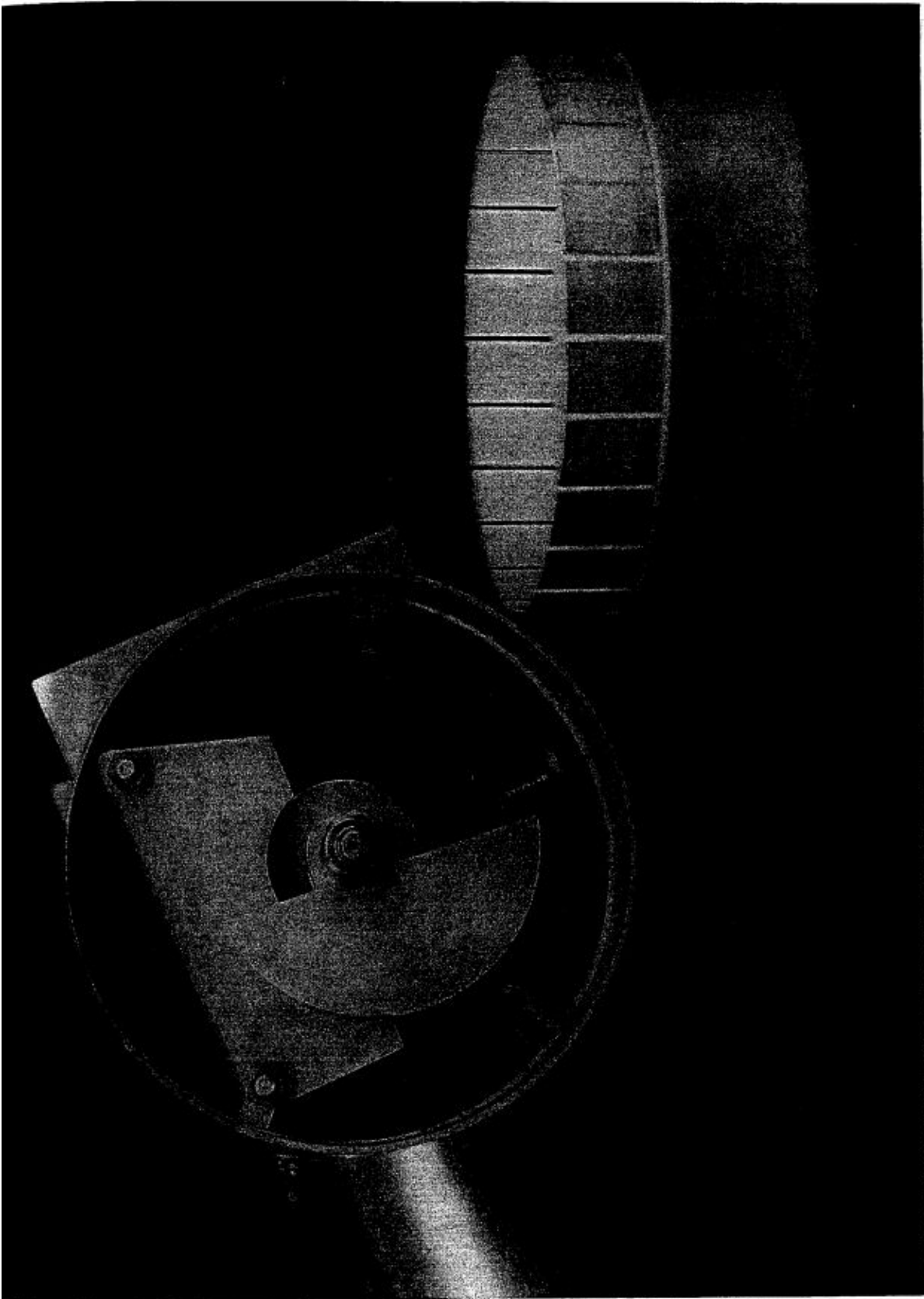


Figure 21 WAVEMETER TUNING CONDENSER

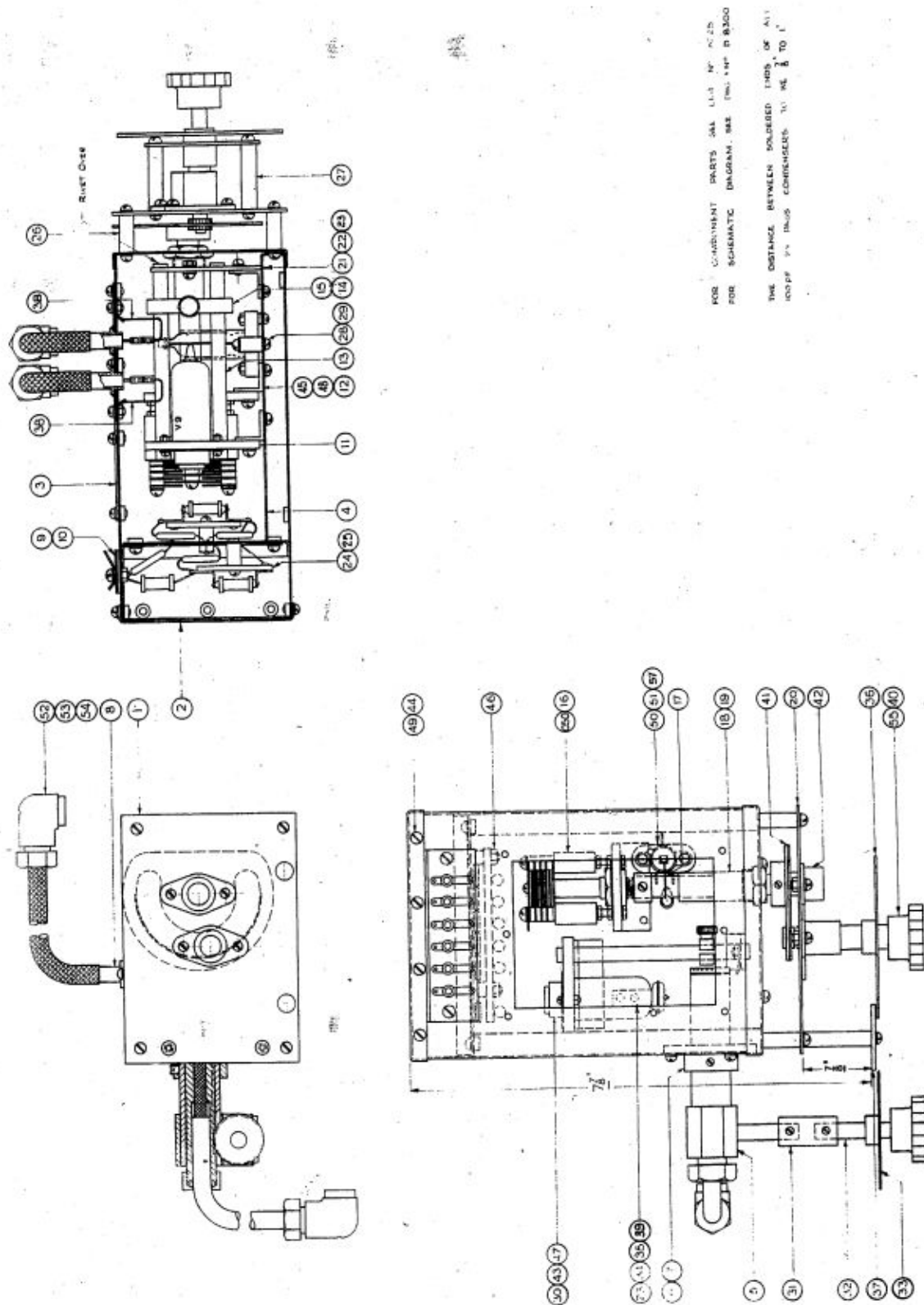


Figure 22. SIGNAL GENERATOR ASSEMBLY

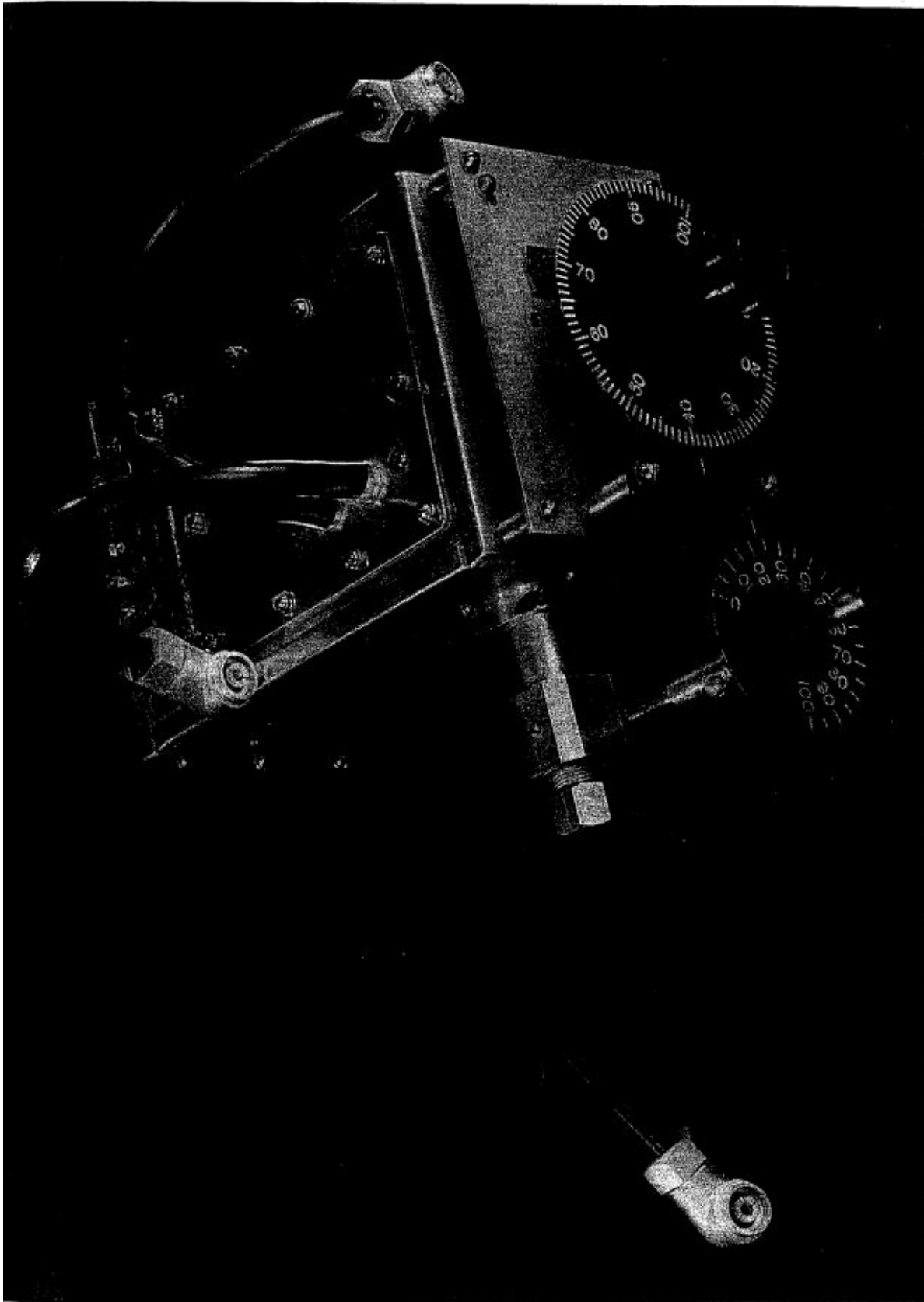


Figure 23 EXTERNAL VIEW OF SIGNAL GENERATOR

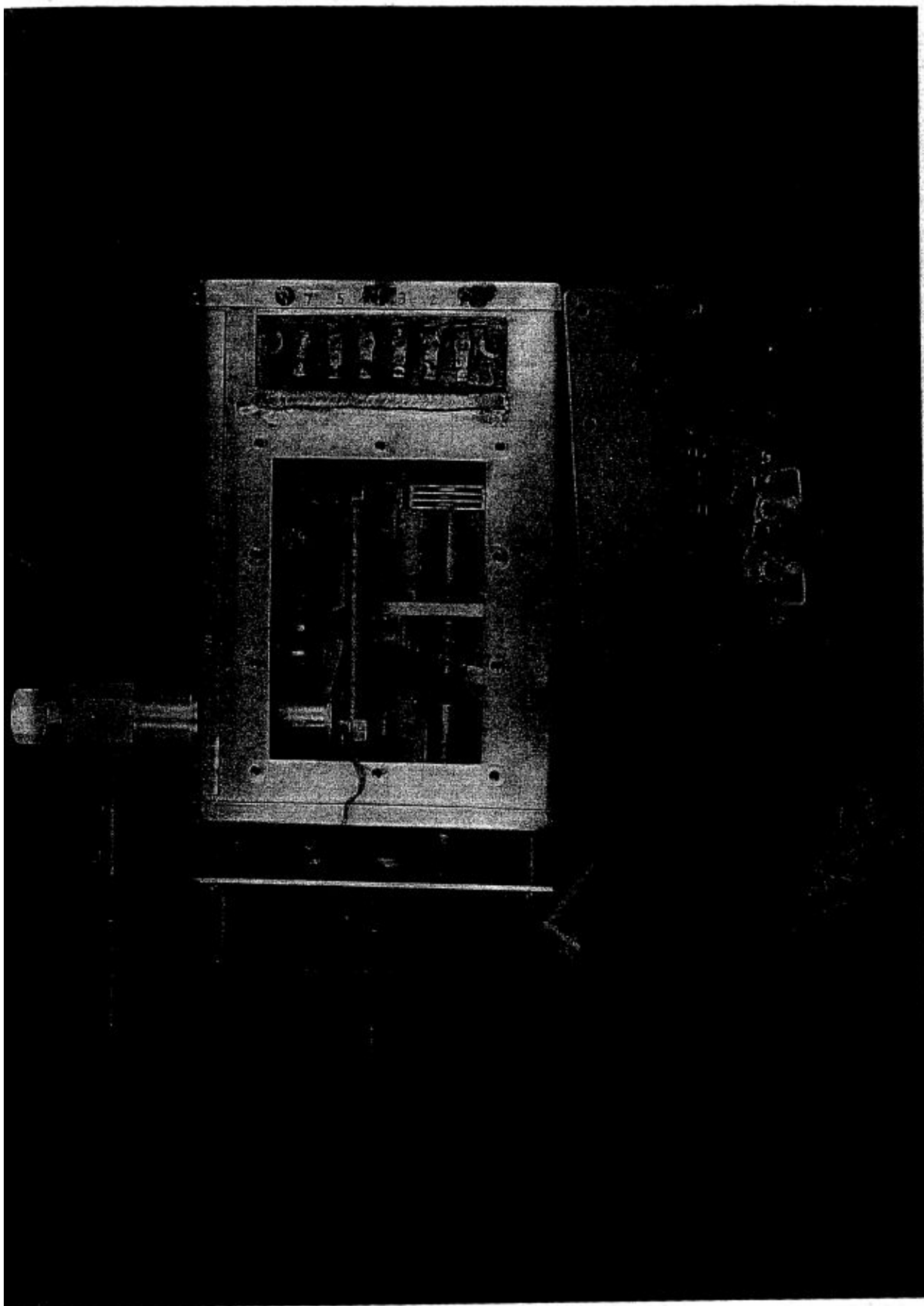


Figure 24 INTERNAL VIEW OF SIGNAL GENERATOR

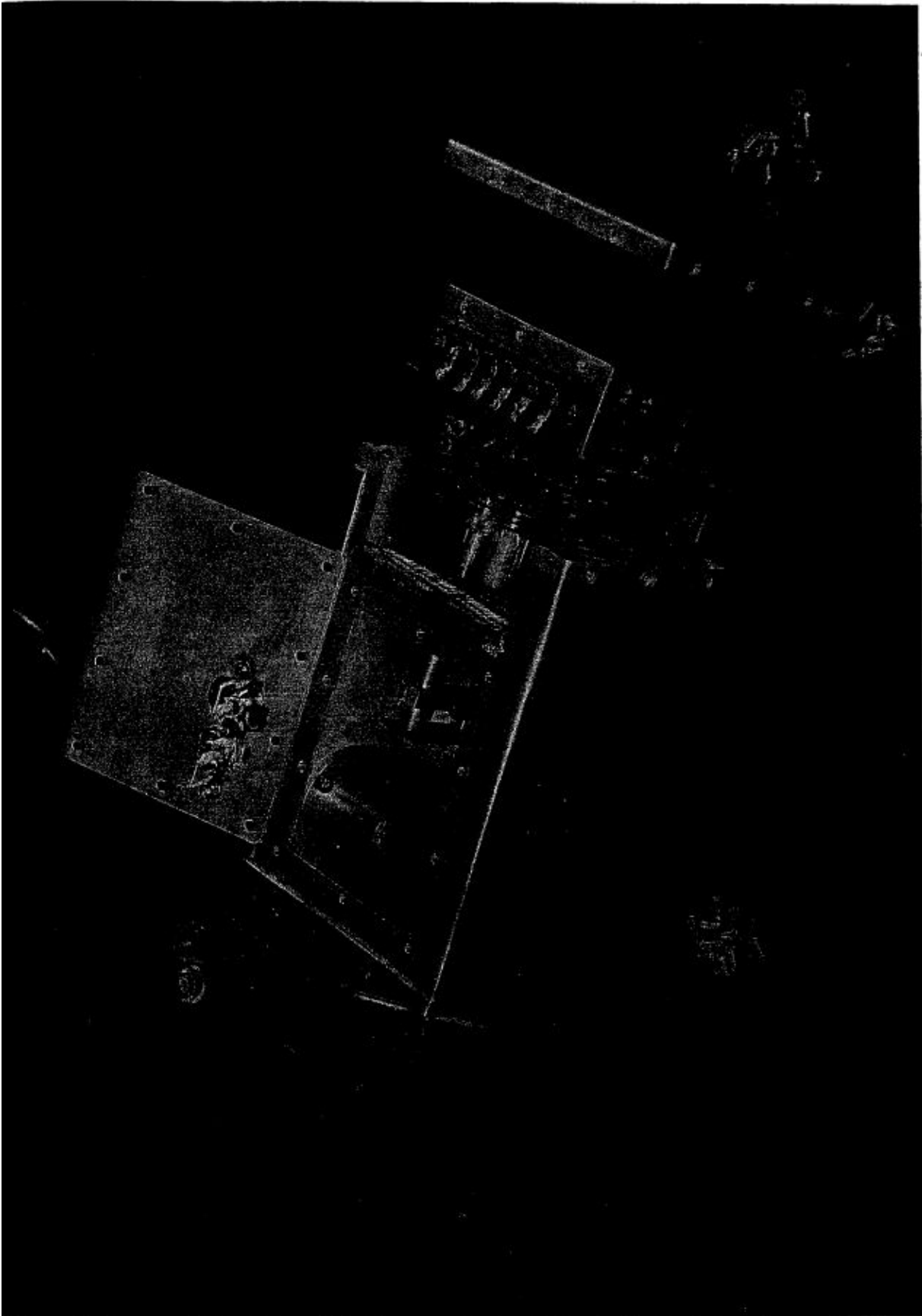


Figure 25 REMOVING THE CHASSIS OF THE SIGNAL GENERATOR

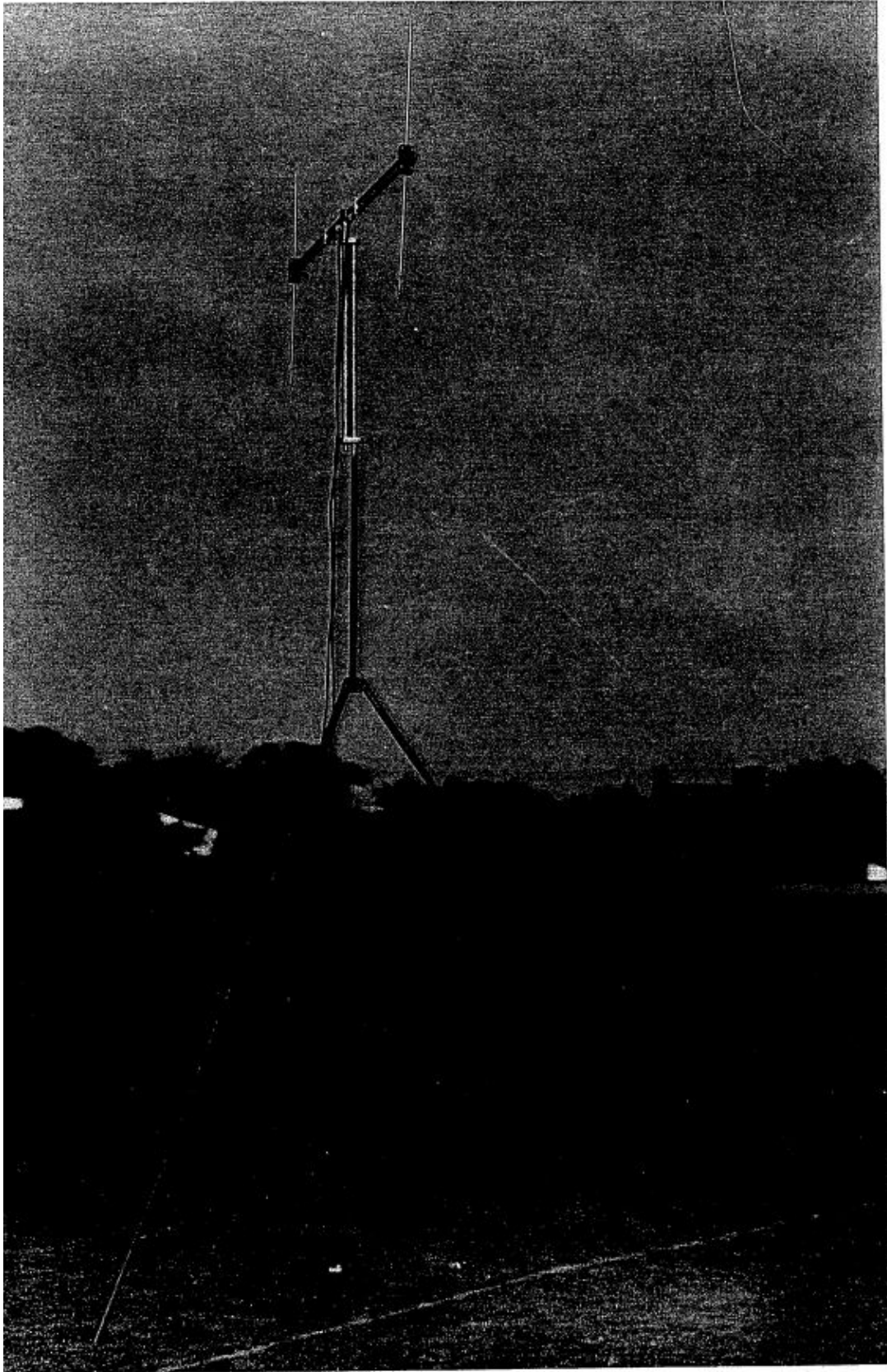
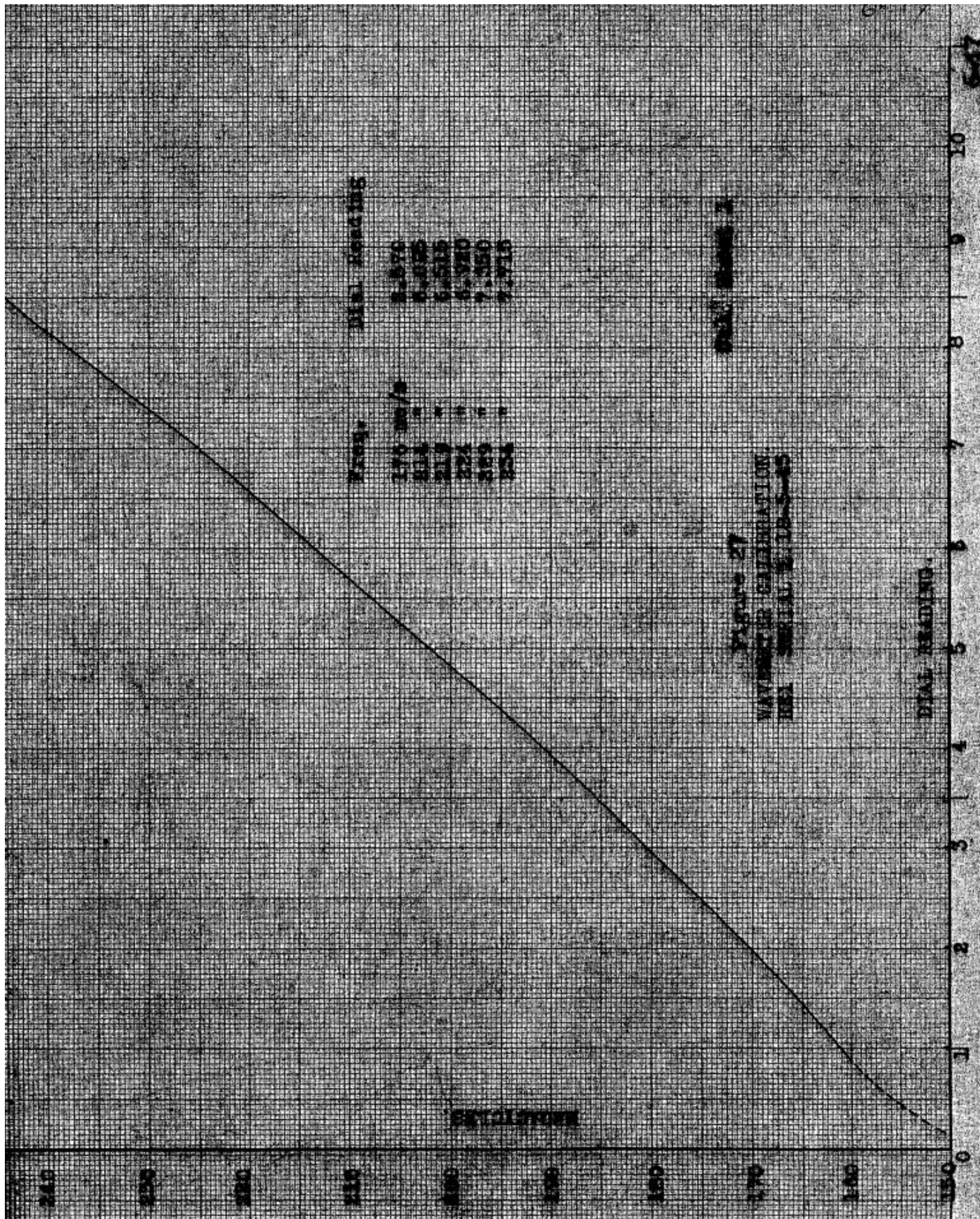


Figure 26 COMPLETE TEST ANTENNA ASSEMBLY

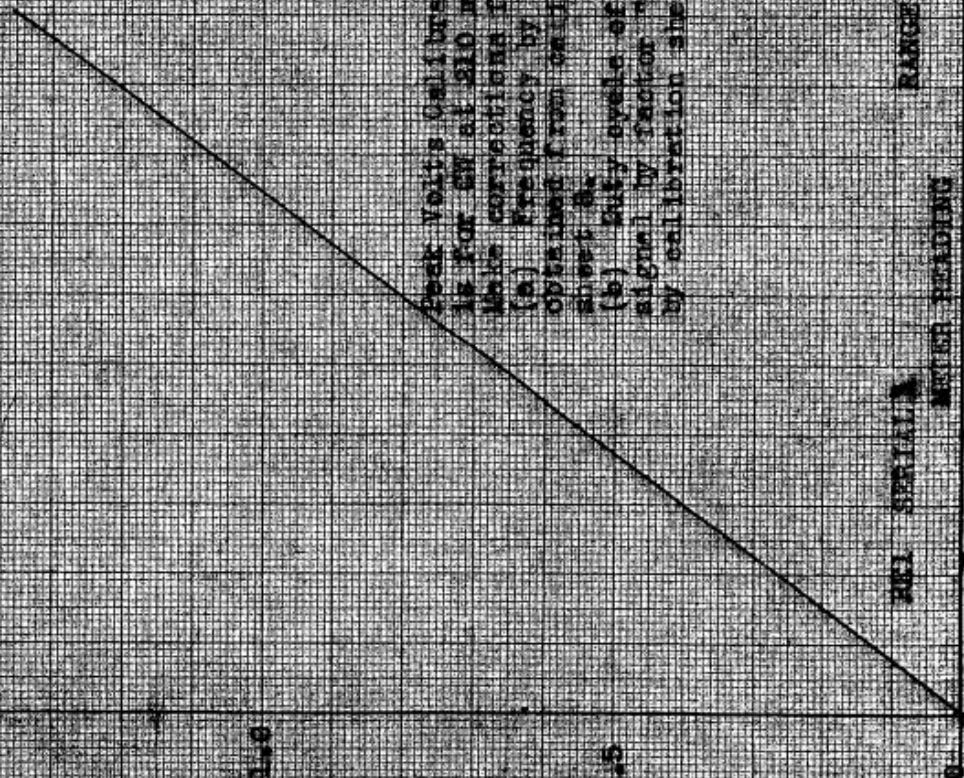


Calibration of R.F. V.T.V.M.

1.25

1.00

PEAK VOLTS R.F.



Peak Volts Calibration
 is for CW at 510 mc/m.
 Make corrections for
 (a) Frequency by factor "a"
 obtained from calibration
 sheet 8.
 (b) Duty cycle of pulsed
 signal by factor "b" given
 by calibration sheet 9.

Cal. Sheet 2

RANGE 1

METER READING

REL. SERIAL

FIGURE 28

Frequency Correction for
Diode Head

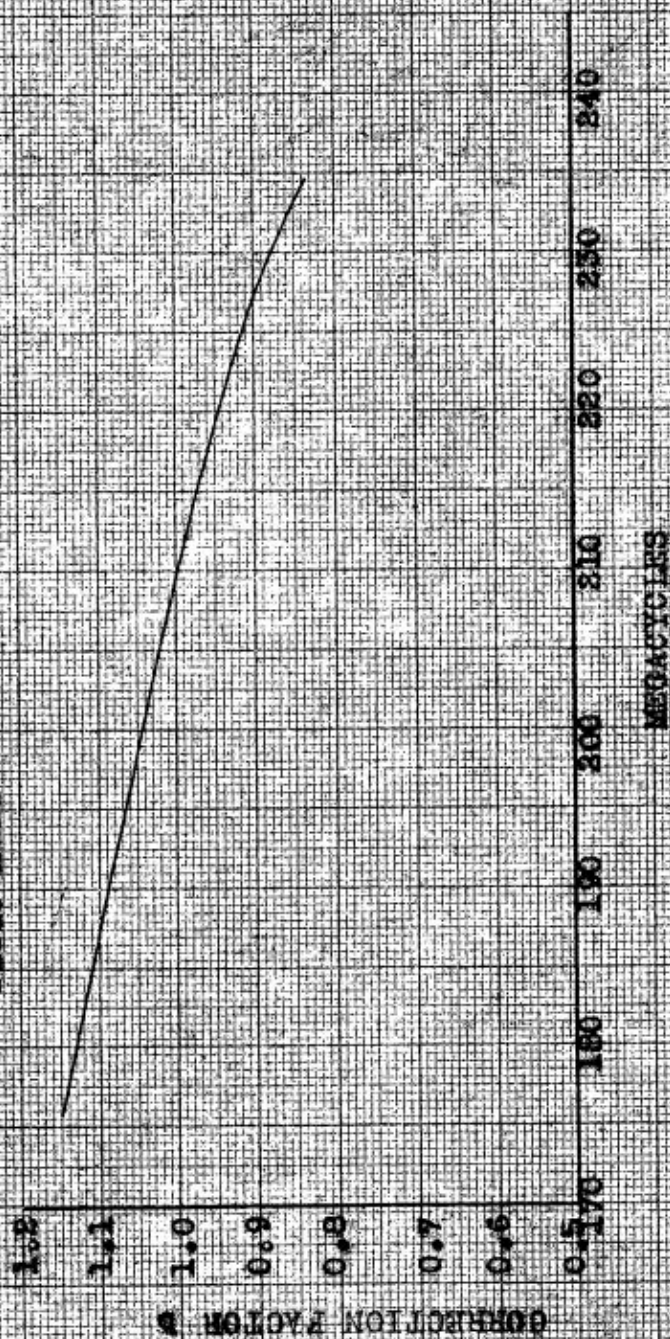
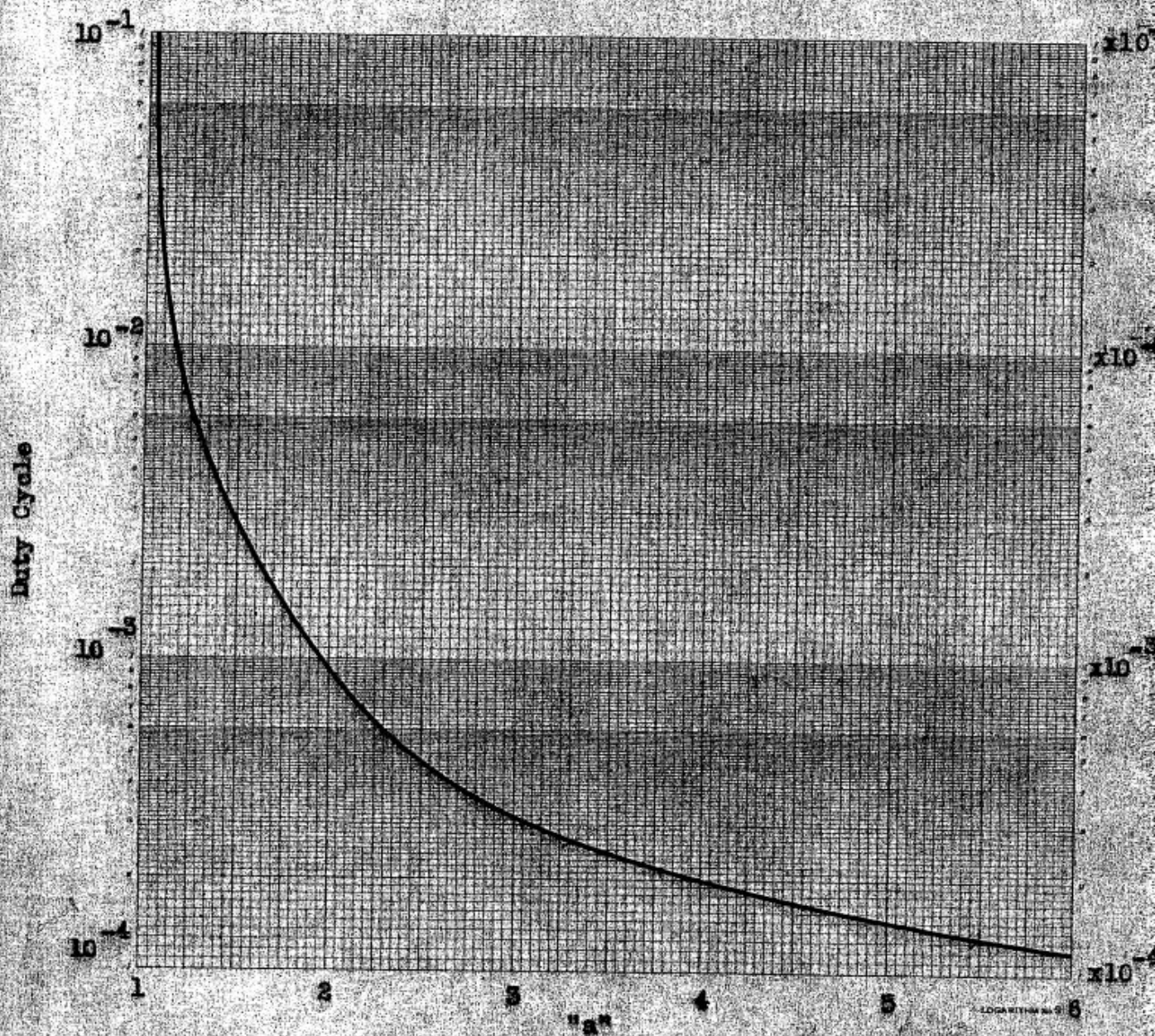


Figure 29. CALIBRATION SHEET 6 (SAME FOR EVERY SET)

Fig. 30. CORRECTION OF VTVM FOR PULSE MEASUREMENTS



Peak Volts of pulsed R.F. = "a" x Reading from C.W. Calibration

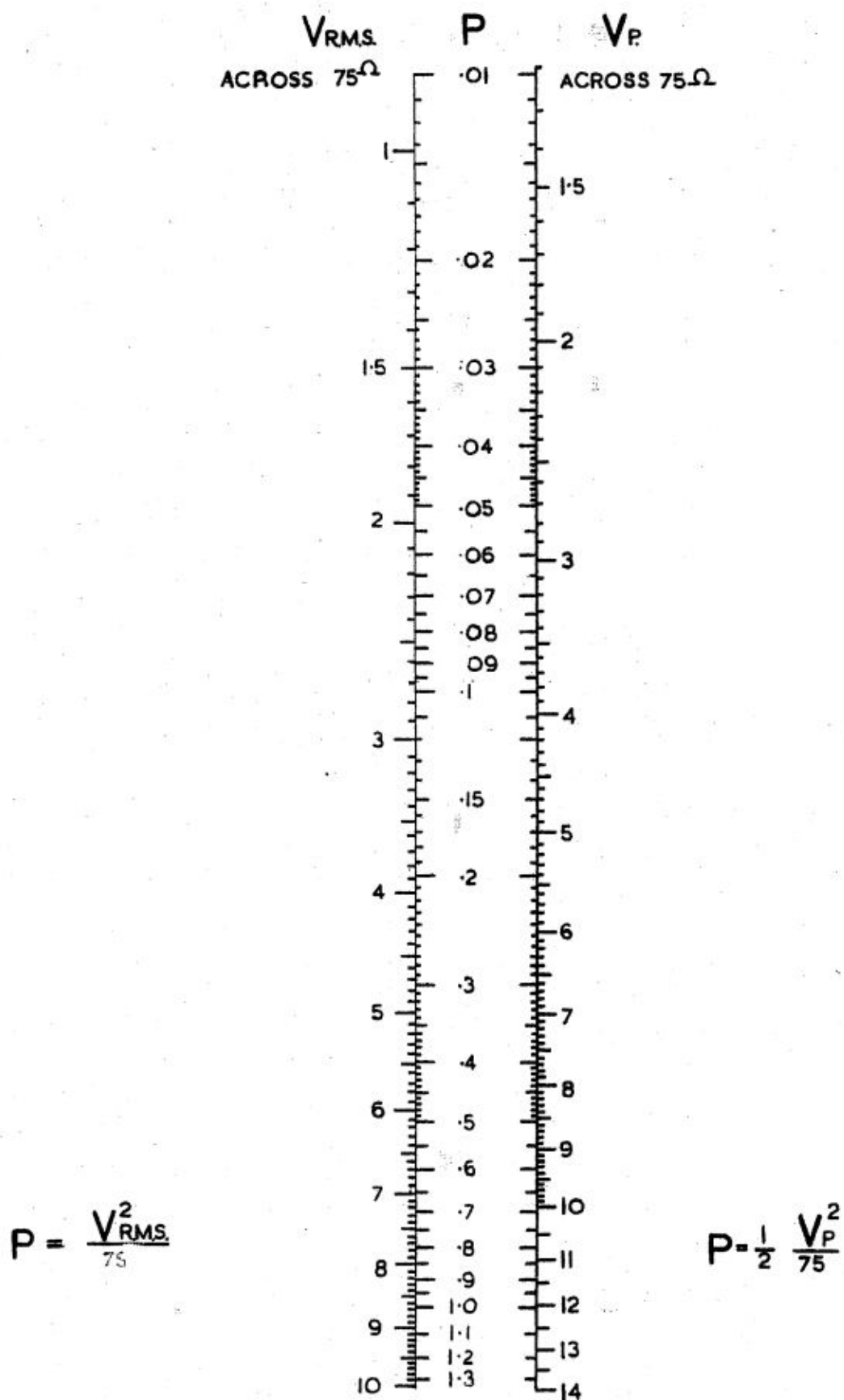


Figure 31

POWER CONVERSION SCALE

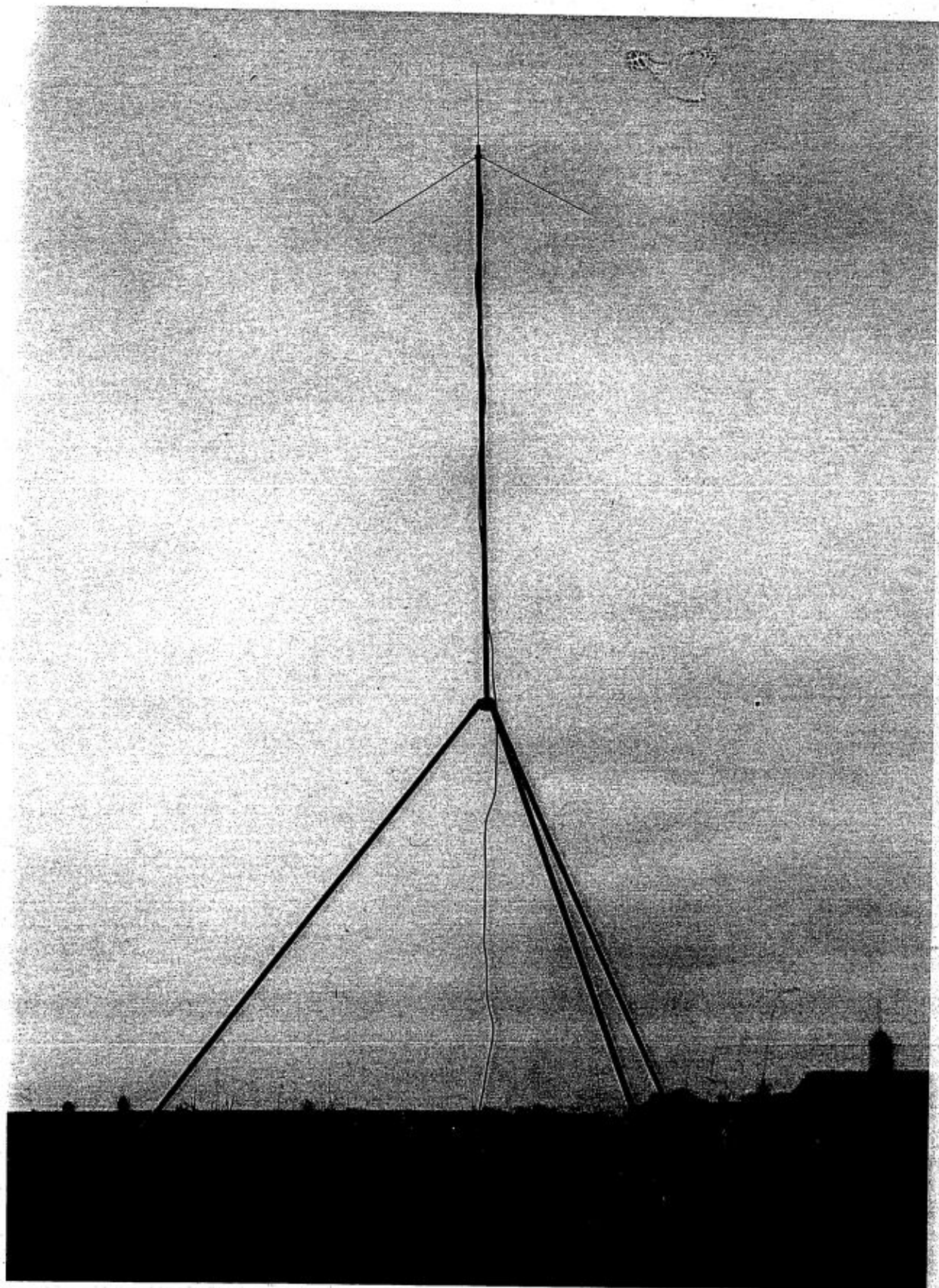


Figure 32 PRODUCTION AERIAL

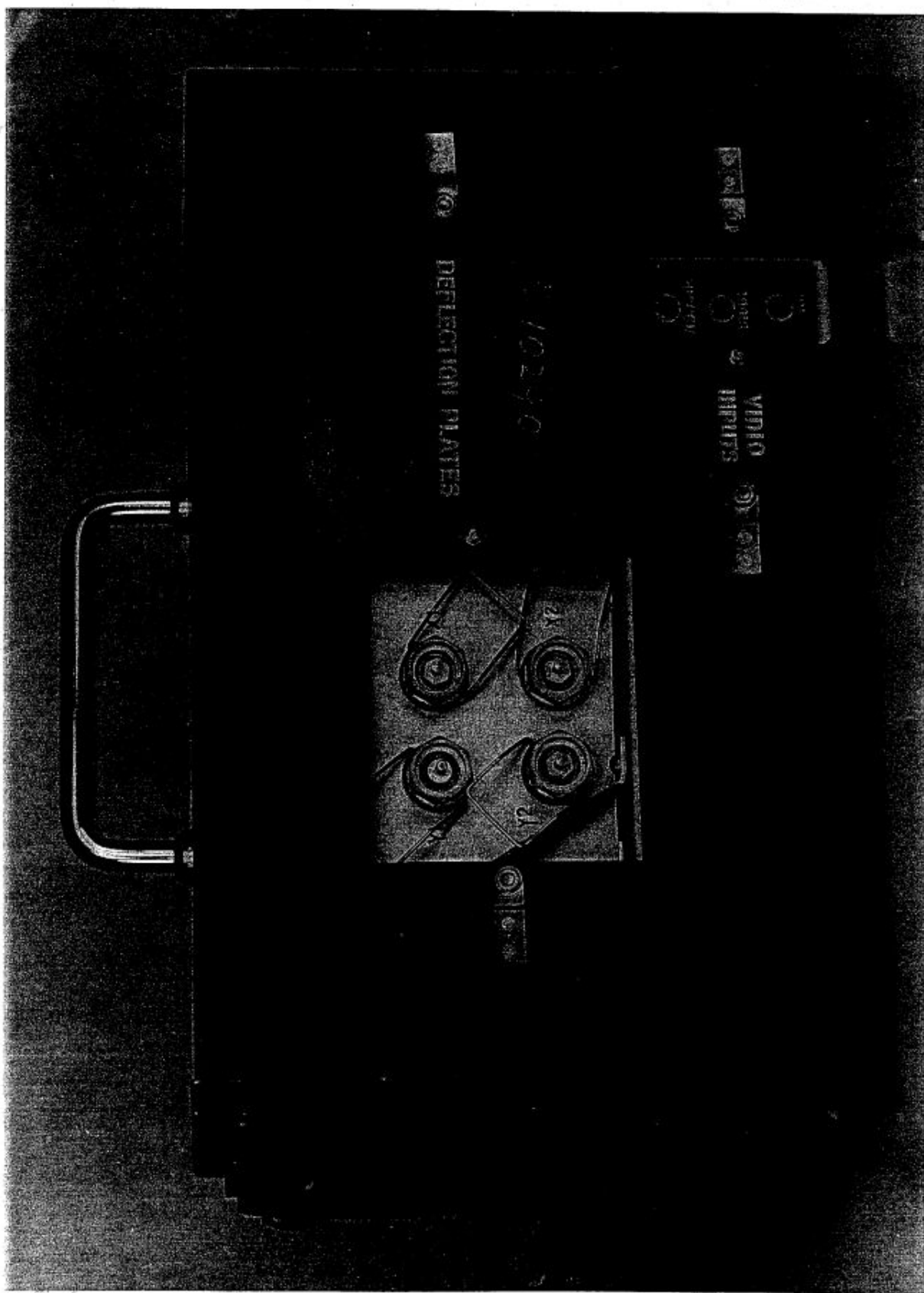


Figure 33. CONNECTIONS TO CATHODE RAY OSCILLOGRAPH

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COUNCIL FOR SCIENTIFIC & INDUSTRIAL RESEARCH

RADIOPHYSICS LABORATORY

SECRET

OUTLINE OF PROPOSED REBECCA-EUREKA TEST SET

By: O. L. Wirsu

OLW/MPH

31st May, 1944

ABSTRACT

The requirements for a test set for Rebecca and Eureka (R.A.A.F. designation R.E.1) are set out, with brief descriptions of the major parts and functions of the set. At this stage, most of the details have not been worked out, but it is expected that the final arrangement will be in accordance with these notes. A very tentative valve list is included.


..... Head of Group
(T.B. Alexander)


C. S. I. R.

Made by C.S.I.R.O.
Industrial Physics

of research or
only

~~SECRET~~

REBECCA-EUREKA TEST SET

R.A.A.F. requirements for test set R.E.1 are set out roughly in their provisional specification.

1. The functions required are:-

(a) Wavemeter

A very accurate, stable, and sensitive wavemeter to measure wavelength of Rebecca-Eureka when placed near aerial. When measuring Rebecca, no other functions are needed, but when measuring Eureka, test set must supply video pulses to trigger the Eureka. It is also required to measure the frequency of the local oscillator in the test set.

(b) Rebecca Range Calibrator

Test set placed in front of aircraft, is to pick up and be triggered by R.F. pulses from Rebecca and to radiate trains of pulses on Rebecca receiving frequency. The pulses in these trains are to be accurately spaced so that they serve as range calibration pips. It is also required to trigger the test set by video pulses from Rebecca's transmitter, and feed video range pips into its indicator. Calibration marks will be provided at intervals of $\frac{1}{2}$, 1, 4, 10 nautical miles.

(c) Rebecca Squint Testing

Test set placed some distance from, and accurately in front of aircraft, and operating as in (b). Squint observed on Rebecca indicator.

(d) Rebecca Receiving System Sensitivity

Test set placed known distance in front of aircraft as in (c), and output from test set adjusted by attenuator to get a given signal/noise ratio in Rebecca. Attenuator setting then gives Rebecca receiving system performance figure.

(e) Rebecca Receiver Sensitivity

Test set triggered by Rebecca's modulator, feeds R.F. pulses directly into Rebecca's receiver, through attenuator.

(f) Rebecca Receiving Aerials

Comparison of (d) and (e) gives a figure for receiving aerial performance, and (c) checks their directional diagrams roughly.

(g) Eureka Sensitivity

Test set placed a standard distance from Eureka and, self triggered, radiates pulses from dipole via attenuator. Earphones plugged into Eureka reproduce

super-regenerator hiss when Eureka is not triggered, chattering when intermittently triggered, and steady tone when steadily triggered. Attenuator readings for these various conditions show performance of Eureka receiver.

(h) Rebecca Power Output

Output of Rebecca transmitter fed into a resistor. Peak voltmeter measures voltage across this resistor.

(i) Rebecca Radiation

Dipole set up in front of aircraft feeds into resistor with sensitive peak voltmeter across it.

(j) Eureka Radiation

Dipole set up near Eureka feeds into test set as in (i), except that amplifier may be needed between dipole and resistor so that voltage to be measured is sufficiently large. Test set must at the same time feed video triggering pulses to Eureka.

(k) Rebecca Transmitting Aerial System

Comparison of (h) and (i).

(l) P.R.F. Meter

Test set placed in front of aircraft, is to pick up R.F. pulses from Rebecca, rectify them and apply to a P.R.F. measuring circuit. P.R.F. meter is also to operate directly from Rebecca modulator. It should also measure P.R.F. of test set when it is self-triggered.

(m) I.F.F. Suppression Check

Test set near aircraft, interrogating I.F.F. set, while Rebecca is operating. Observe suppression on Rebecca indicator.

2. Major parts of set

The major parts of the set can be summarised:-

a) Wavemeter

High Q coaxial inductance with precision tuning condenser across it. Diode mounted directly on inductance to serve as detector. Inputs to come from outside terminal and from local oscillator of test set. Output from diode to go to d.c. amplifier and meter.

b) Power measurement - High power (Rebecca output)

Output from Rebecca to be fed into small resistor with peak diode voltmeter across it. Diode output goes to common d.c. amplifier, as in (a).

(c) Power Measurement - Medium power (Rebecca Radiation)

As in (b), except that full sensitivity of voltmeter is used, instead of being reduced as in (b). Dipole used to pick up R.F.

(d) Power Measurement - Low power (Eureka radiation)

As in (c), except that it may be necessary to insert amplifier between input and resistor + diode.

(e) Tunable 200 Mc Oscillator / Signal Generator

Two alternatives are available:-

- (i) Pulsed oscillator with diode amplitude indicator built in, diode to work with d.c. amplifier and meter.
- (ii) C.W. oscillator followed by pulsed amplifier. Diode amplitude indicator to be located wherever possible.

Of these alternatives, (i) is to be preferred on grounds of simplicity if it can be made to produce sufficiently clean pulses of about 2 μ secs length.

(f) Pulser

A pulser is required to control (e), the pulse length being determined by a small pulse forming line.

(g) Multivibrator/Flip-flop

To function as flip-flop when externally triggered, or triggered by pulses from rectifier of (c). When pulsing without external triggering is required, it is to function as multivibrator. In both cases it is to trigger either pulse (f) or ringing oscillator (h).

(h) Ringing Oscillator

To be triggered by flip flop when calibration pips are required. Its output is fed to pulser (f).

(i) Attenuator

To go on output of oscillator (e).

(j) P.R.F. Meter

To be triggered either by video pulses or rectified R.F. pulses from (c).

(k) D.C. Amplifier

To work in conjunction with meter and all peak diodes as required.

(l) D.C. Milliammeter

For circuit checking, and for use with (j) and (k).

(m) Dipoles

Two broad band dipoles, one to connect to oscillator (through attenuator), the other to go to (c). This allows receiving and transmitting functions to be separate when test set is being triggered by Rebecca.

(n) Power Supplies

The set is to operate with either 240 V A.C. or 24 V D.C. power supplies. It is probable that one power unit will do this, using a non-synchronous vibrator when supplied with D.C.

3. Tentative Valve Complement

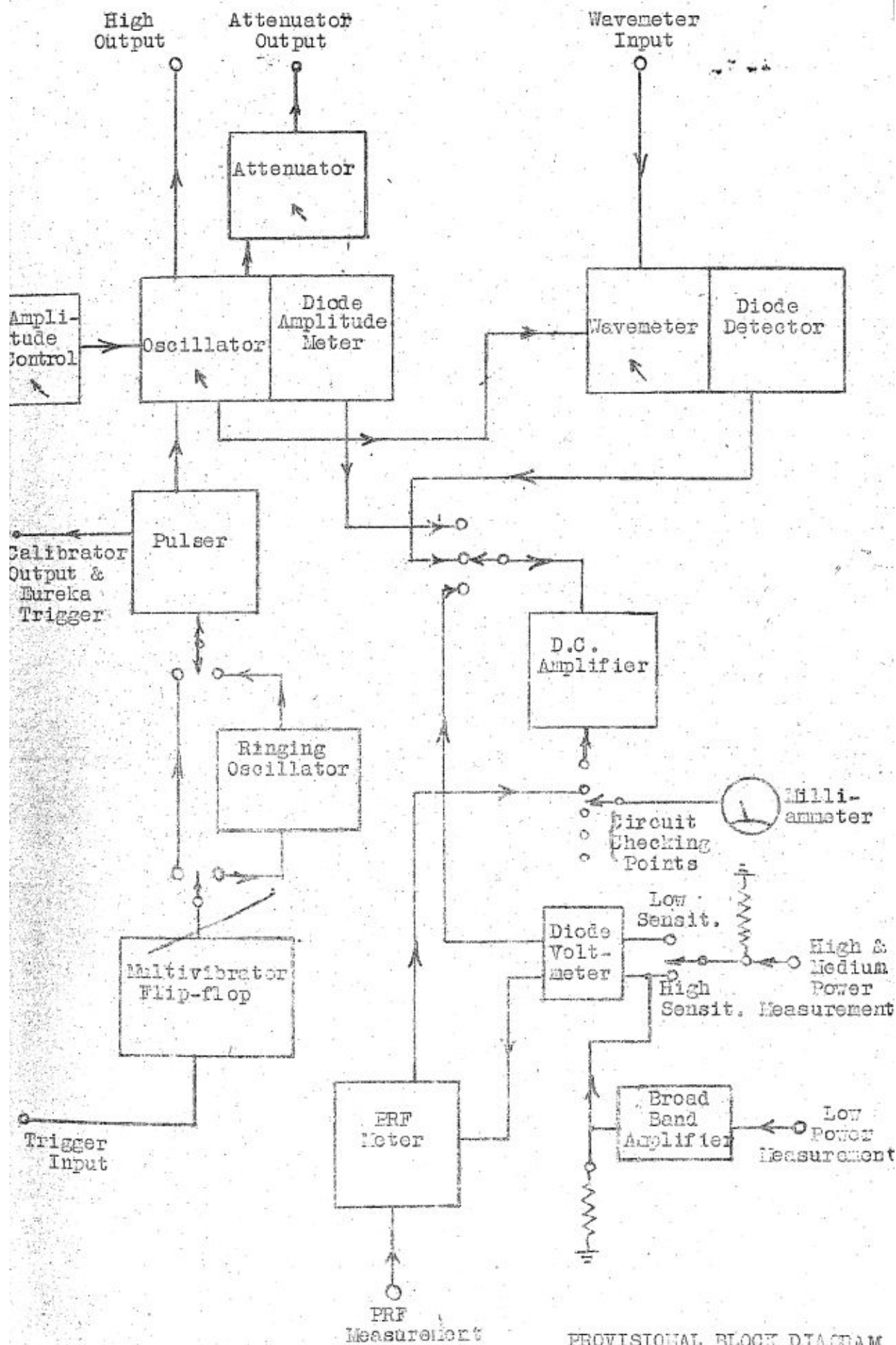
The following is a tentative list of valves required for the test set. Some changes may become necessary as design progresses, but all persons concerned will be notified immediately any decisions are made. The arrangement of valves depends of course, on the types required being available.

Function	Valve Type	Quantity
Multivibrator - Flip-flop	6SN7GT	1
Calibrator Oscillator	6SN7GT	1 $\frac{1}{2}$
Pulser	6SN7GT	2
Oscillator (H.F.)	6J6	1
Oscillator Monitor Tube	EA50	1
Wavemeter Detector	EA50	1
D.C. Amplifier	6J6	1
Power Measuring Diode	EA50	1
PRF Meter	884	1
Voltage Regulator	VR150/30 ^{RE}	1
Power Supply	6X5GT	2
Power Measuring Amplifier	6AK5	1

Total

6SN7GT	3
6J6	2
6AK5	1
EA50	3
884	1
VR150/30	1
6X5GT	2

* If VR150/30 is unobtainable, VR105/30 will do.



PROVISIONAL BLOCK DIAGRAM

COUNCIL FOR SCIENTIFIC & INDUSTRIAL RESEARCHRADIOPHYSICS LABORATORYTEST ON AS10/PPNI EUREKA AERIAL

By: H. N. Edwardes

HNE:JAS13th July, 1944.ABSTRACT

This report deals with measurements of directional diagrams, gain and impedance of the American Eureka aerial type AS10/PPNI.

Comparisons have been made between this aerial and the locally developed Eureka aerial type U844.

Tests were carried out on St. Paul's Oval during the period 5:6:44 to 19:6:44.

Rebecca frequencies A, C, and E, and frequency P were used in these experiments.

I DESCRIPTION OF EQUIPMENT.(a) Aerial AS10/PPNI.

This is a light-weight, collapsible aerial. Fig. 1 is a sketch of the unit. The mast consists of eight sections strung together on a thin wire cable held in by spring tension. The design is such that the sections are all drawn together when unfolded.

The antenna, which forms the top section of the mast, consists of three rods as shown in Fig. 2a. The vertical rod (a quarter-wave radiator) is a continuation of the inner conductor of the feeder. The outer conductor terminates in the two inclined rods (trap rods).

The feeder is 12 feet of Uniradio 32 co-axial polythene cable.

(b) R.P. Eureka Type U844.

This aerial is represented in Fig. 2b. The lengths (a) and (b) are variable by means of sliding sections of tube.

(c) Dipole.

Fig. 2c represents the dipole used for comparison purposes. The feed is from Uniradio 1 co-axial cable, through a balance-unbalance matching transformer. The lengths l_1 and l_2 were adjusted for minimum standing wave ratio in the feeder at 2.6 frequency.

II METHODS.

(a) Aerial Diagrams.

The aerial under test was made rotatable about a vertical axis, and used for receiving radiation from a fixed transmitter about 100 yards distant. The variation of received signal with aerial azimuth was observed.

(b) Gain.

Comparisons were made between signals received on the various aerials when set up, in turn, at the same height and in the same position.

(c) Impedance.

For this a standing wave detector was used, consisting of a slotted section of co-axial transmission line, of 75 ohms characteristic impedance, with a travelling probe.

III EXPERIMENTAL RESULTS.

(a) Directional Diagrams.

These are plotted on polar co-ordinates in Fig. 3. The quantities plotted are azimuth angle and relative voltage of received signal. The notes on the diagrams explain the various arrangements.

(b) Gain Measurements.

TABLE A.

FREQUENCY	GAIN					
	R.P. U844 (Ex) Db.	AS10/PPNI Vert. Db.	Rel. Gain	AS10/PPNI Horiz. Db.	Rel. Gain	Dipole Db.
A	0	.25	1.1			
C	0	-.5	0.9	-10	0.3	
E	0	1.25	1.3			
P	-7	-7	0.45	-20	0.1	0
1	2	3	4	5	6	7

Setting of elements in U844 ($a_1 = 13\frac{3}{8}"$)
Note - Compare results horizontally only ($b_1 = 12\frac{3}{8}"$)

~~SECRET~~

The above table contains the results of measurements on the experimental model of the R.P. type U844 aerial, the AS10/PPNI and a matched dipole (L997, adjusted for P frequency).

The letters A, C and E in column 1 refer to Rebecca frequencies.

Columns 3 and 4 contain results for AS10/PPNI in normal position with vertical polarisation from the transmitter, while for the results of 5 and 6 horizontal polarisation was used. Columns 4 and 6 contain figures of voltage gain of AS10/PPNI, relative to U844 for frequencies A, C, E and relative to the dipole for frequency P.

TABLE B.

FREQUENCY	Matched Dipole Volts	AS10/PPNI Volts	U.844 Volts	a ₁ in.	b ₁ in.
C	1	1	1	13½	12½

This is the result of comparisons between gains of the three aeriels at C frequency.

TABLE C.

FREQUENCY	GAIN				a ₁ in.	b ₁ in.
	AS10/PPNI		U844 (P)			
	Db	Rel. Gain	Db	Rel. Gain		
A	0	1	-4.5	.59	13½	12½
C	0	1	0	1	13½	12½
A	0	1	-2	.80	11½	14
C	0	1	-3	.69	11½	14
A	0	1	-1.5	.83	13½	14

NOTE:- Compare results horizontally only.

These results are for comparisons between AS10/PPNI and U844 prototype (as distinct from the experimental model) for different frequencies and settings of the elements of U844.

(c) Impedance.

TABLE D. FREQUENCY C.

AERIAL	STANDING WAVE RATIO	LOSS DUE TO REFLECTION Db
AS10/PPNI	1.45	.2
U844 (Ex)	1.1	0
U844 (Pr)	1.1	0

This table contains values of standing wave ratio in the feeders of the aerials, at frequency C.

IV DISCUSSION OF RESULTS.

(a) Directional Diagrams.

Note:- The relation between aerial setting relative to transmitter, and azimuth is as indicated in the small diagram at the bottom right hand corner of Fig. 3: for 0 bearing, the plane of the rods is perpendicular to the direction of the transmitter.

Diagrams A, B, C. (Vertical Polarisation, Frequencies A,C,E.)

For a bearing of 0, currents of equal amplitude and phase flow in the two inclined trap rods. It is presumed that the lengths and inclination of the trap rods have been adjusted to produce equal currents in the inner and outer conductors of the co-axial feeder.

For a bearing of 90° , the currents in the trap rods would be out of phase, so that the resultant current in the outer of the feeder would not be equal to the current in the inner. Thus current flows on outside of braid, and the voltage at the receiver would be a minimum. The diagrams show about a 10% difference between maximum and minimum.

Diagram E. (Horizontal Polarisation, Frequency C.)

For 0 bearing, there is no current in the vertical rod, while currents in trap rods are equal and opposite. Thus total current into feeder is zero, and signal is a minimum.

Another minimum occurs at 90° , since all the rods are then perpendicular to the electric vector.

In intermediate positions, the currents in the trap rods are out of phase and cause currents to flow in the feeder. These will be unbalanced also. Thus a "four-leaf clover" diagram results.

Diagram H. (Horizontal Polarisation, Frequency P.)

At this frequency the balancing arrangement would probably be upset, so that the braid of the cable would be touchy. This was confirmed experimentally. This would perhaps account for the distortion in the diagram.

Diagram F. (Vertical Polarisation, Frequency P.)

This should be similar to the vertical diagram of a dipole. The currents in the trap rods add vectorially at the centre. This sum is not always equal to the current in the other rod so that current flows down the braid. The displacing of the maxima by about 30° is probably due to this.

Diagram G. (Vertical Polarisation, Frequency P.)

In this case the currents in the trap rods are always equal in magnitude and phase and the maxima occur at 90° and 270° as in the case of a dipole.

(b) Gain.

The most important difference between the AS10/PPNI and U844 is that the former is able to receive a reasonable amount of horizontal polarisation (10db down on vertical polarisation, or $\frac{1}{3}$ voltage).

Even on P frequency the horizontal pick up is 13 db down on vertical ($\frac{1}{4}$ voltage).

At C frequency both aerials have the same gain as a matched dipole (table B).

Comparing tables A and C, there appear to be differences between the experimental and prototype versions of U844, although the settings of a_1 and b_1 , for a match, are almost the same in both aerials.

Losses due to mismatch are negligible (table D).

V CONCLUSIONS.

(a) AS10/PPNI and U844 each have the same gain as a matched dipole at C frequency.

(b) AS10/PPNI has a wider frequency band than U844.

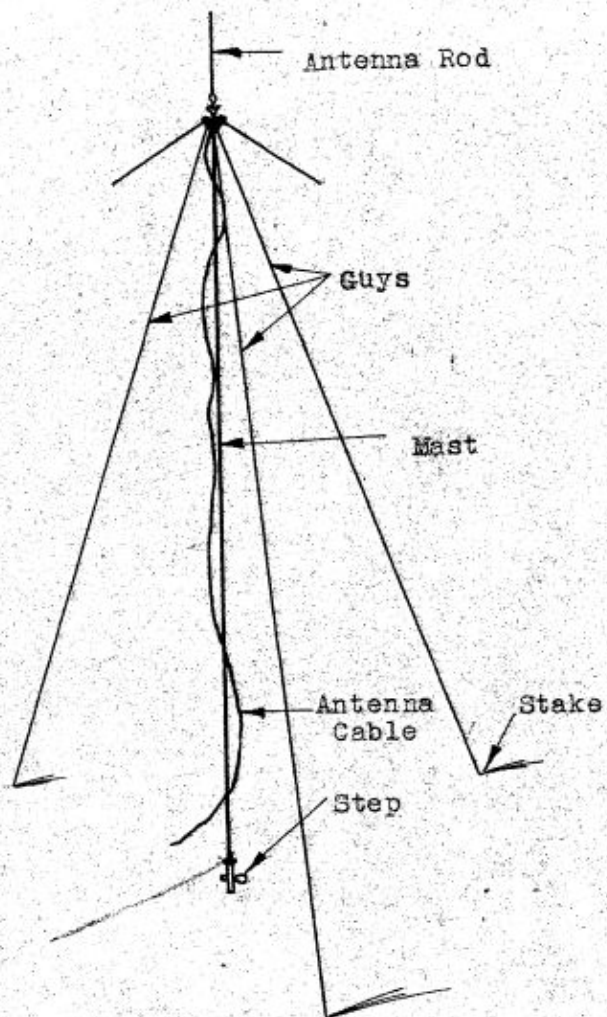
(c) AS10/PPNI has considerable horizontal pick-up at P frequency.

VI COMMENTS.

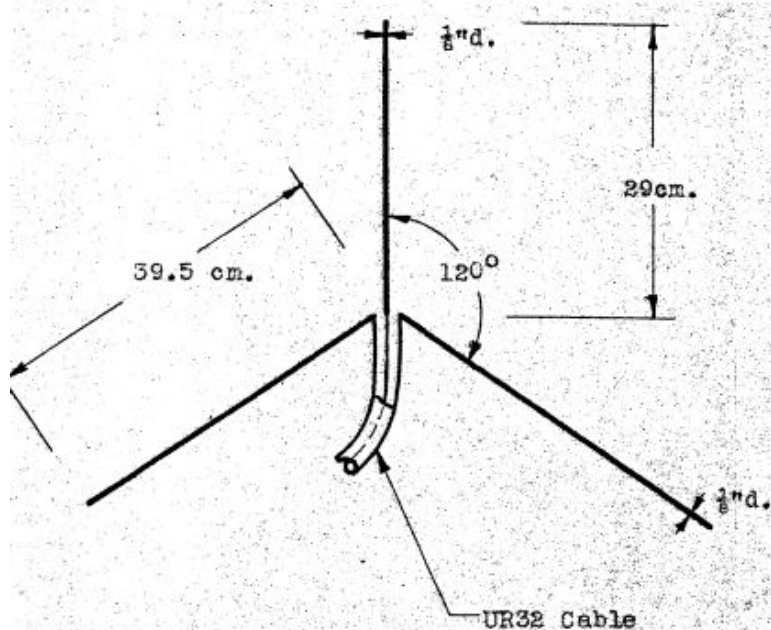
It is difficult to reconcile conclusion (a) with the fact that AS10/PPNI responds to horizontal as well as vertical polarisation. Possibly, the aerial is more directive than a dipole in the vertical plane.

From (c) there is a remote possibility of using the AS10/PPNI for Eureka in conjunction with A.S.V.

.....
(J. L. Pawsey)
Head of Group.

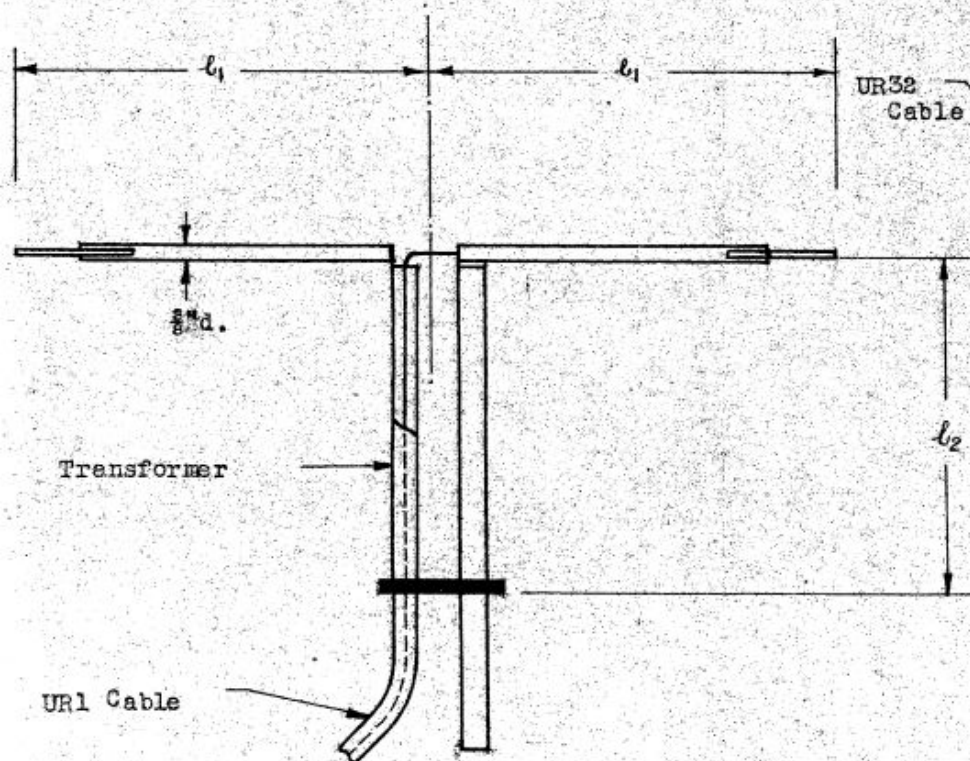


AERIAL ASSEMBLY.



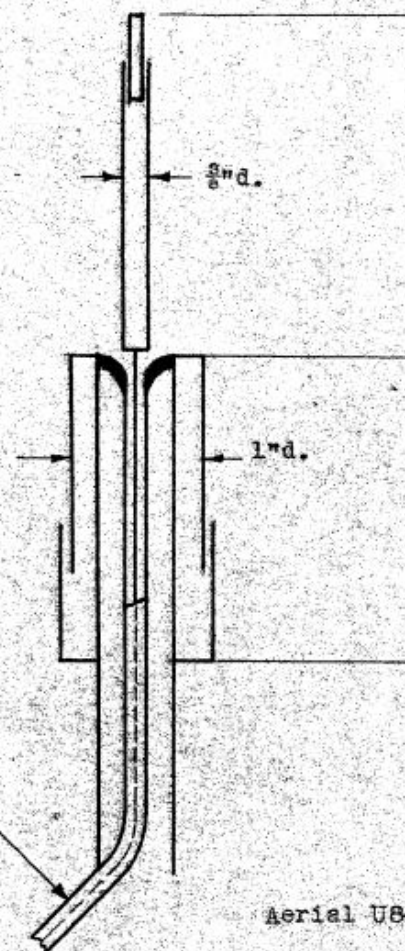
Aerial AS10/PPNL

Fig. 2a



Dipole

Fig. 2c

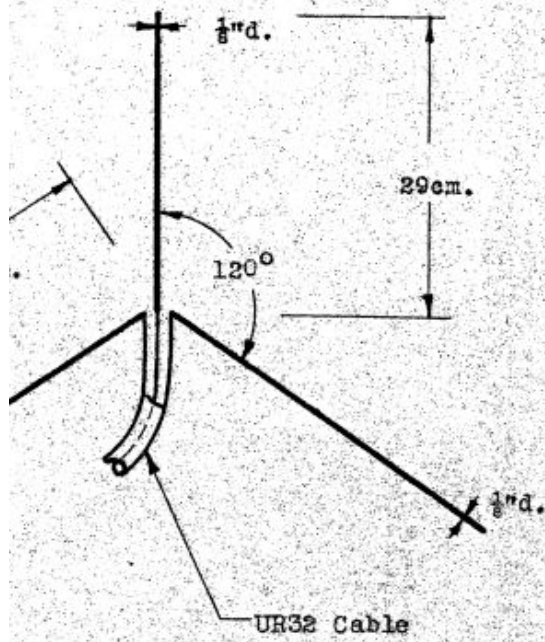


Aerial U84

Fig. 2b

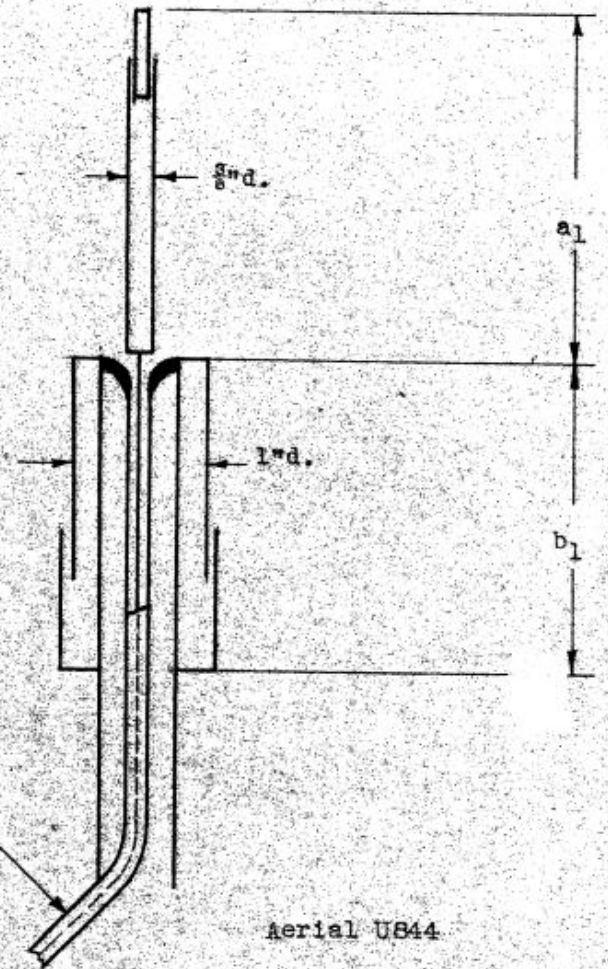
LEFT

FIGS. 2A 2B, 2



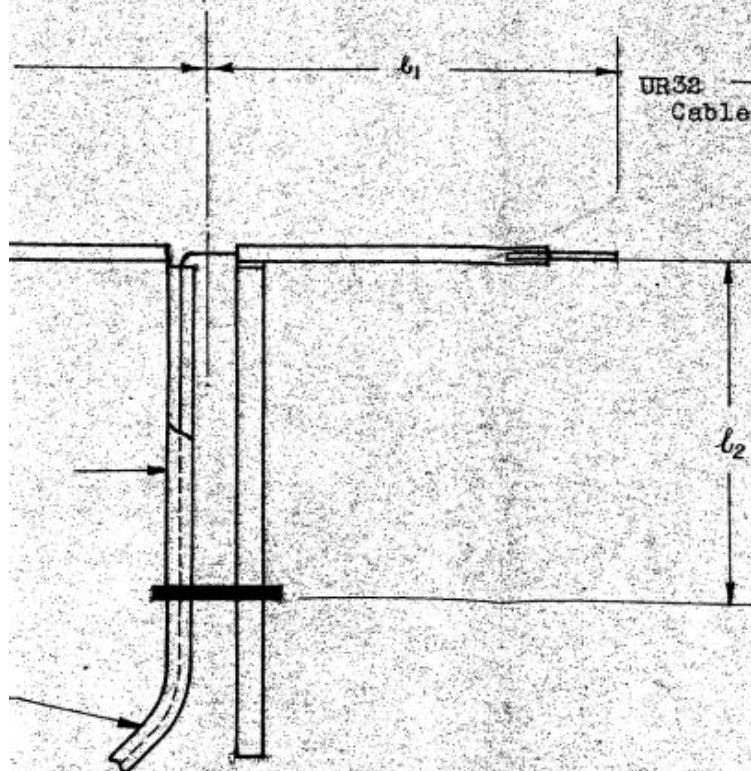
Aerial AS10/PPN1

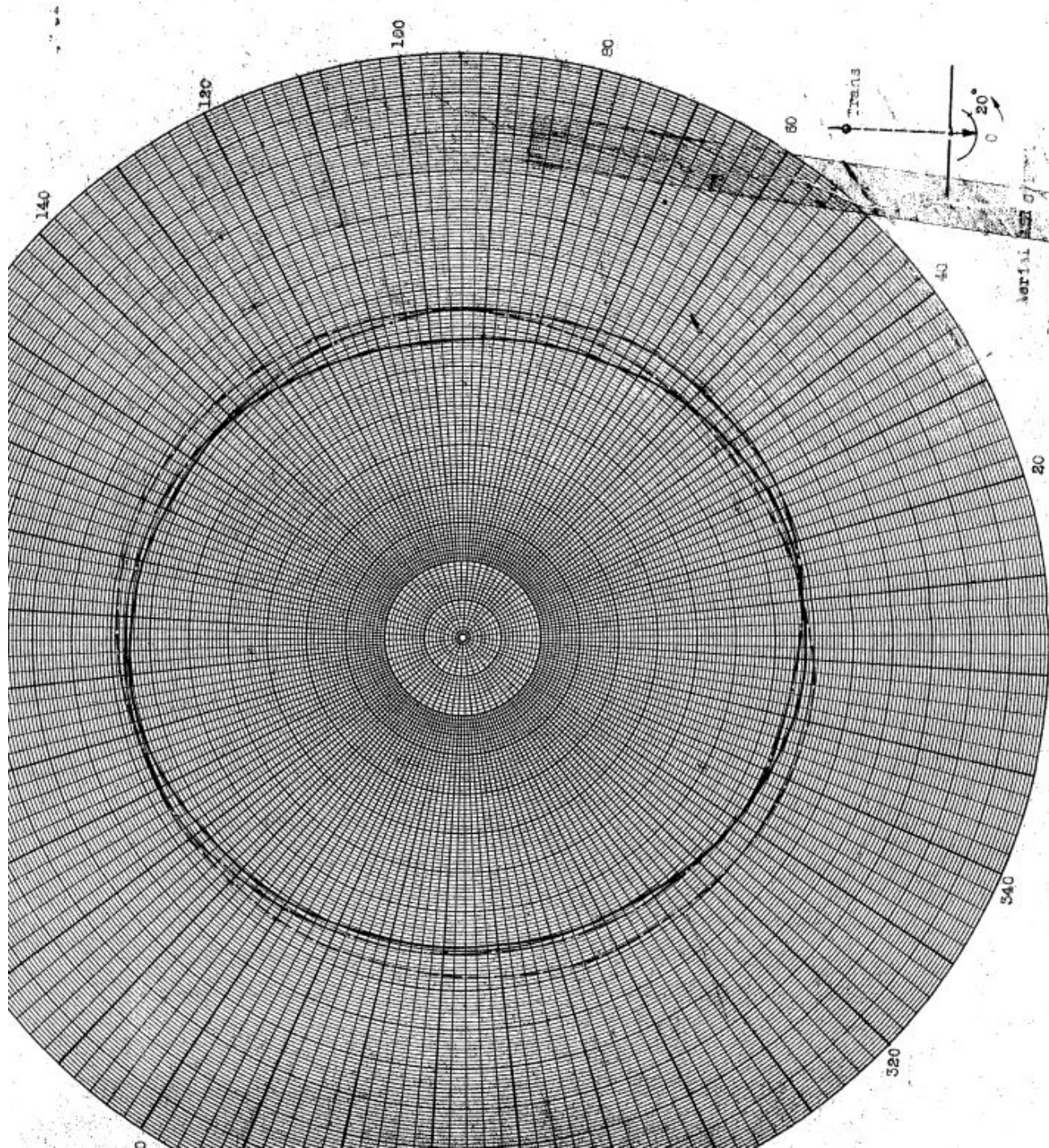
Fig. 2a



Aerial US44

Fig. 2b

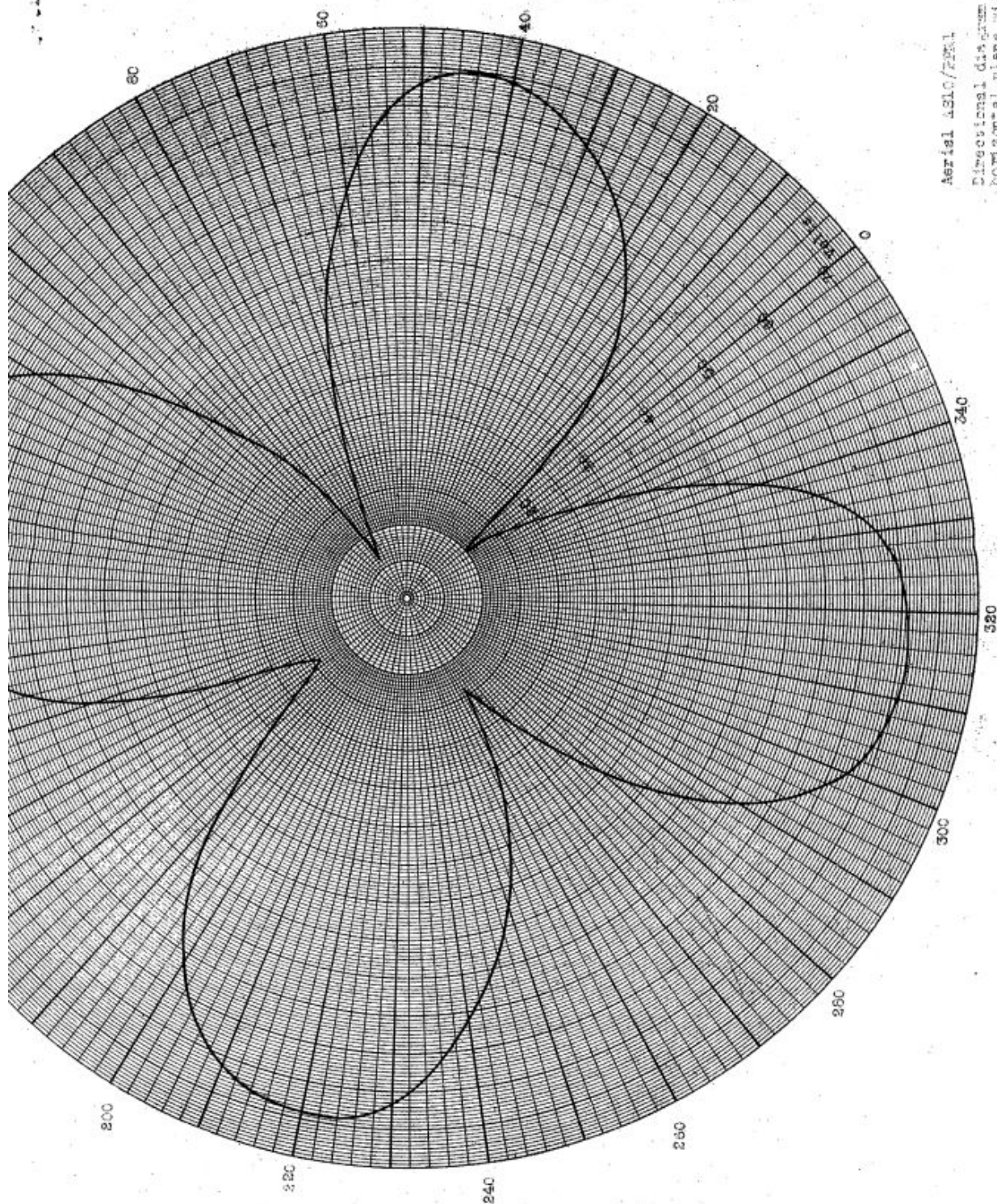




Aerial 1000 ft

Directional diagram in horizontal
plane, with vertical polarization

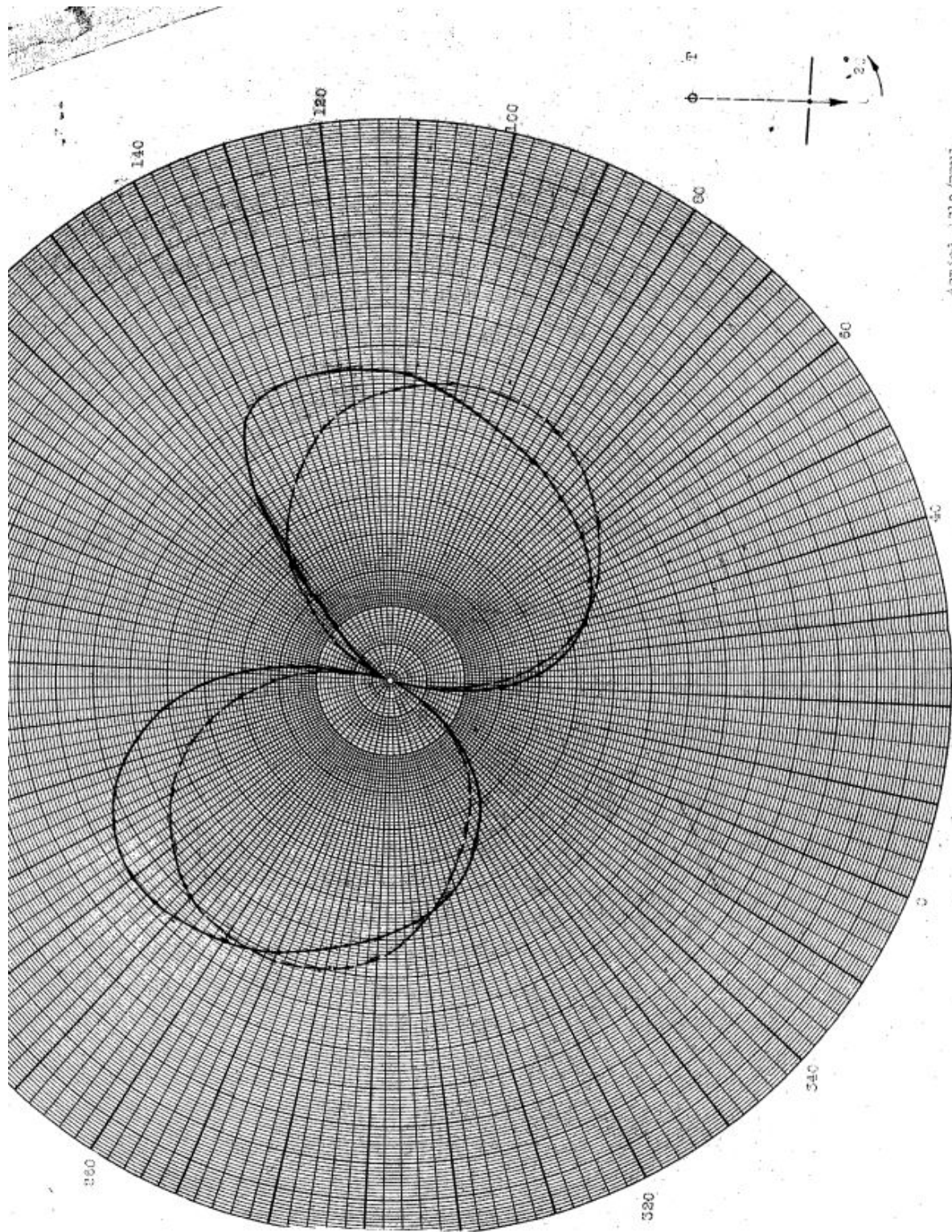




Aerial 4310/2701

Directional diagram in
horizontal plane with horizontal
polarization

1 - 200000



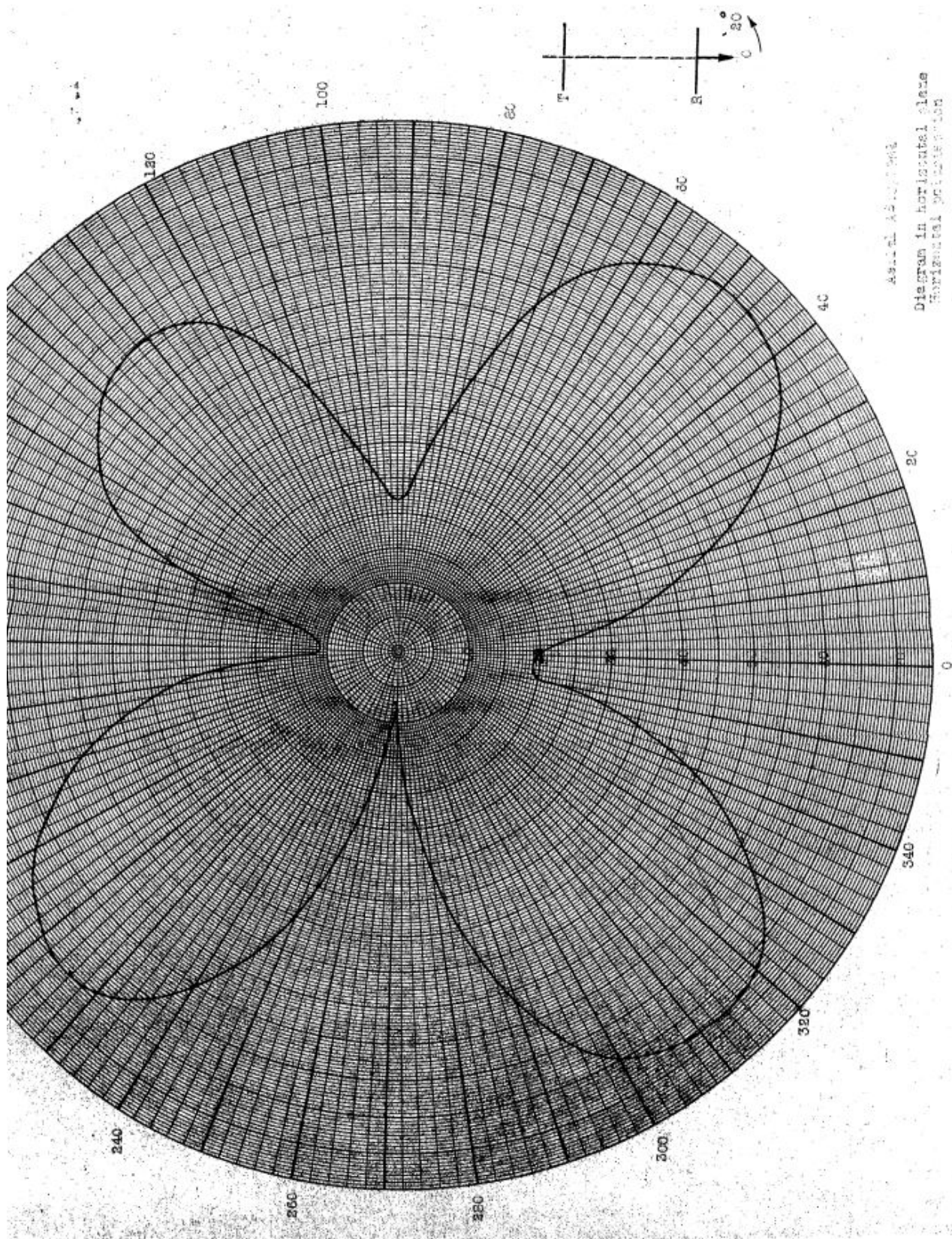
Aerial 1310/27N1

Vertical Polarisation
Diagram in Vertical Plane

$\lambda = 7$

6 --- " L to rods
7 --- " with rods

G119



AS-111 15-10-1961

Diagram in horizontal plane
Horizontal projection

$\ell = 2$

08113